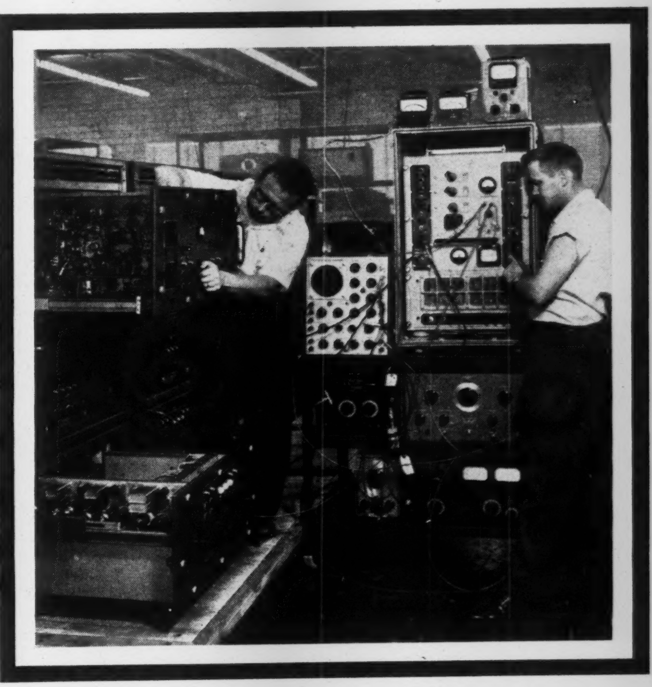
INSTRUMENTS and AUTOMATION

Phys.



Radar and MTI • Page 478

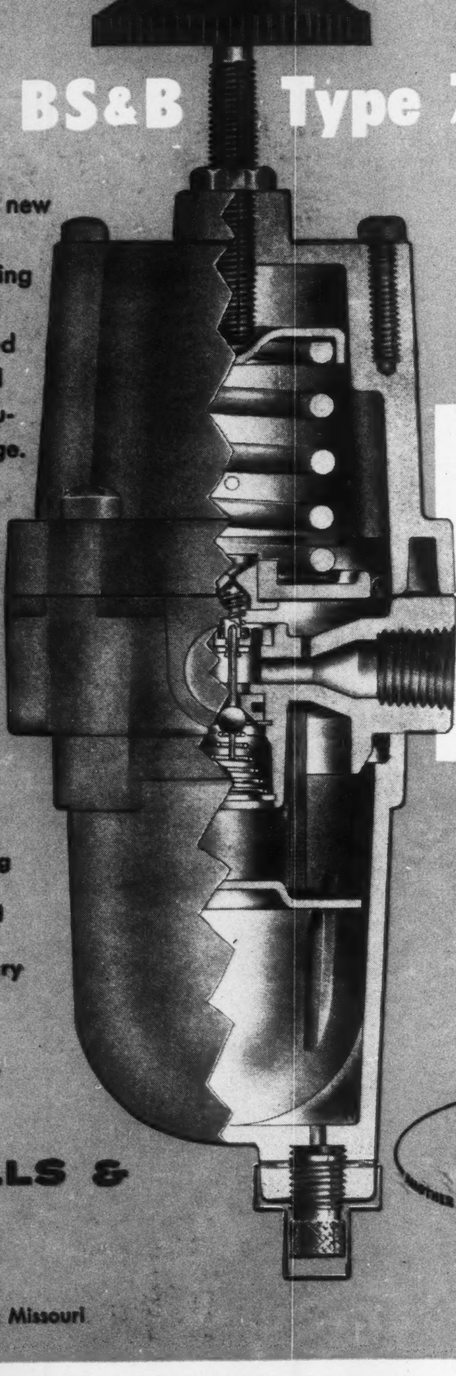
cluding:
strument Manufacturing
e Journal of the SCMA
ulation Council Newsletter

VOL. 29 NO. 3 MARCH 1956

INTRODUCING . . .

Today's Finest Instrument Air Regulator!

It's The New BS&B Type 73-26!



We invite your comparison of the new BS&B Type 73-26 Instrument Air Regulator with any other make being offered today. When you've seen the differences and have compared performance data, we know you'll agree the 73-26 is the *finest* instrument air regulator in its price range.

1/4" Pipe Connections

40 PSI—Maximum Reduced Pressure
(100 PSI with Special Spring)

300 PSI—Maximum Input Pressure

10 CFM—Maximum Capacity

FEATURES

- **Higher Air Volumes.**
- **Improved Corrosion Resistance.**
- **40 Micron Phenolic Impregnated Cellulose Filter.**
- **Minimum Pressure Drift From Set Point.**
- **Instantaneous Response To Changes In Flow Rate.**
- **Easy Adjustment To Within Close Limits For Any Pressure Within Its Output Range.**
- **Can Be Serviced Without Removing From Air Line.**
- **Can Be Panel Or Bracket Mounted If Desired.**
- **Available With Or Without Auxiliary Pressure Gauge.**

For complete information, contact your BS&B Representative, or communicate directly with . . .

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V3
7500 East 12th Street, Kansas City 26, Missouri

EFFICIENCY
OVER 60 YEARS
BS&B
RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

For more information circle **1** on inquiry card.

PERKIN
power supplies

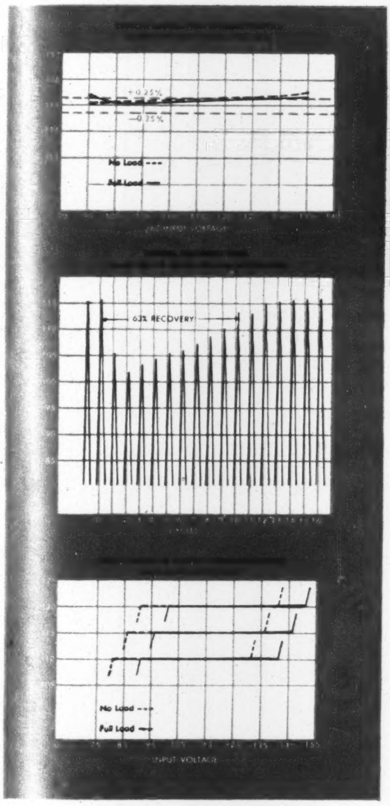
PERKIN ANNOUNCES

IMMEDIATE DELIVERY

on a NEW TUBELESS!

MAGNETIC AMPLIFIER

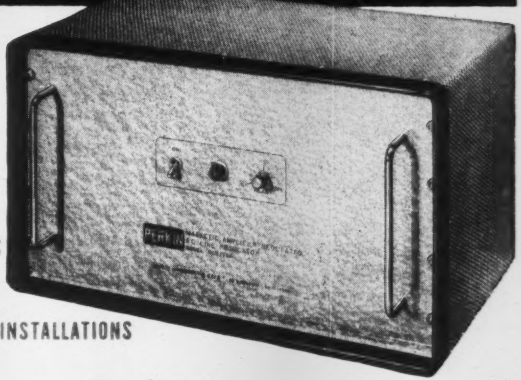
AC LINE VOLTAGE REGULATOR



MODEL MLR - 1000

1 KVA

- ☆ NO TUBES TO REPLACE
- ☆ NO MOVING PARTS
- ☆ NO VIBRATING CONTACTS
- ☆ REGULATES RMS VALUE
- ☆ IDEAL FOR UNATTENDED INSTALLATIONS



Specifications...

- **Input Voltage Range:** 95 to 135 volts
- **Output Voltage:** Nominal 115 volts. can be adjusted from 110 to 120 volts.
- **Output Current:** 8.5 amperes
- **Regulation Accuracy:** ±0.25% for any combination of line or load
- **Frequency Range:** 60 cycles ±10%
- **Wave Form Distortion:** 3% maximum
- **Power Factor Range:** 0.5 lagging to 0.9 leading
- **Response Time:** 0.2 sec.
- **Maximum Load:** 1.0 KVA
- **Ambient Temperature Range:** Up to 45° C.
- **Dimensions:** 19½" wide x 11" high x 11½" deep (cabinet)
  19" wide x 10½" high x 11½" deep (rack panel)
- **Mounting:** Cabinet or 19" Rack Panel
- **Finish:** Gray Hammertone
- **Weight:** 85 lbs.

Perkin also manufactures a complete line of standard DC Power Supplies. The following is a partial listing:

VOLTS	AMPS	REG.	MODEL
0-32	25	±1%	M60V
24-32	10	±½%	28-10WX
24-32	30	±½%	28-30WX
5-40	30	±1%	MR 1040A
24-32	100	±½%	100 XA

Ripple on all above models: 1% rms

For a full listing and complete specifications, write for Bulletin C-56.

PERKIN
power supplies

Representatives in principal cities throughout the country.
Wire collect for complete price information.

PERKIN ENGINEERING CORP.

345 KANSAS ST. EL SEGUNDO CALIF. PHONE: OREGON 8-7215

For more information circle **2** on inquiry card.

if it's **METAL FABRICATION**

your **FALSTROM** man has the answer!

cabinets
panel boards
small parts
enclosures
cubicles
housings
chassis
consoles

- fabrication of large or small shapes to close tolerances.
- fabrication in aluminum, sheet steel, stainless steel, copper, brass and other alloys.
- complete design-engineering-production service.
- stock tools, dies, jigs . . . standard fabricating techniques employed wherever possible.
- modern facilities for punching, shearing, bending, welding, finishing.

Falstrom means it's that much better!

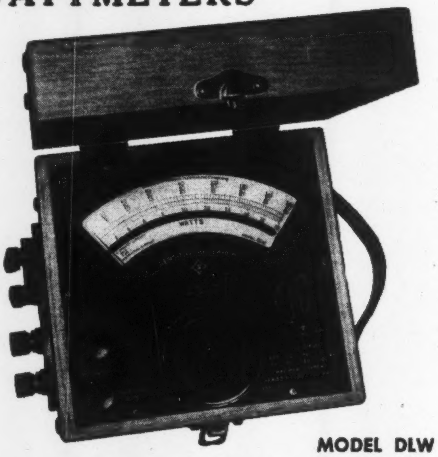
F ALSTROM

FALSTROM COMPANY, 92 Falstrom Court, Passaic, N. J.
PRescott 7-0013
Since 1870

For more information circle **3** on inquiry card.

Sensitive Research

LOW POWER FACTOR
WATTMETERS



MODEL DLW

Down to 5% power factor. Accuracy .5%. AC-DC 25 to 1000 cps. 5.2" hand drawn mirrored scale. Electrostatic and magnetic shielding.

MODEL DW—Down to 50% power factor. .25% accuracy. AC-DC 25 to 1000 cps. 6.3" hand drawn mirrored scale. Electrostatic and magnetic shielding.

VOLT-AMP-WATTMETER

Accuracy .5% down to 50% power factor.

TWO MODELS. a. 50-133 cps., 21 ranges, 12.5 W. to 5 KW. full scale. b. 50-800 cps. 16 ranges, 50 W. to 5 KW. full scale. Switch controlled. 5.2" hand drawn mirrored scale.

VISIT BOOTH NO. 278 NEW YORK IRE SHOW AT KINGSBRIDGE ARMORY MARCH 19-22.

Inquiries Invited—Write Dept. IA 10.

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

Symbol of Quality — ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

For more information circle **4** on inquiry card.

Richard Rimbach, Publisher
Milton H. Aronson, Editor
Fred D. Marton, Managing Editor
Manoel F. Behar, Editor Emeritus
James Emge, Associate Editor
David S. Aland, Associate Editor
Milo D. Pugh, Western Editor
John H. McLeod, Jr., Associate Editor
(Simulation Council Newsletter)
Armand T. Gaudreau, Consulting Editor
(Automation)

District Offices and Managers

Altadena, Calif., Milo D. Pugh & Associates: M. D. Pugh, 2721 N. Marengo Ave., SYcamore 7-2894; Hunter Vinton, 1050 Lincoln Ave., Palo Alto, Calif., Davenport 5-4815

Boston 16, Mass., Harold H. Short, Jr., Holt Road, Andover, Mass., Andover 2212

Chicago 1, Ill., Harold W. Haskett, Room 1205, 228 N. La Salle St., Central 6-8963

Cincinnati 5, Ohio, Harold W. Haskett, 742 Elberon Ave., Grandview 1-4323

Dallas, Texas, Edward F. Wright, 505 N. Ervay, Rm. 310. Prospect 0189

Detroit 2, Mich., Blanchard W. Cleland, 8242 Woodward Ave., Trinity 37480

Kansas City 6, Missouri, Thomas W. Wright, 18 East 11th St., Telephone BAltimore 7305

New York 17, N. Y., Richard Rimbach, Jr., 525 Lexington Ave., Rm. 359, Murray Hill 8-0980

Philadelphia, Pa., Robert H. Maxwell, 7 Wilde Ave., Drexel Hill, Pa., Clearbrook 9-4342 (Phila. Suburban)

Pittsburgh 12, Pa., C. Goldcamp, 845 Ridge Ave., Fairfax 1-0161

St. Louis 1, Mo., Stephan E. Wright, 706 Chestnut St., Chestnut 1-1965

London. W.1, England, John C. N. Hughes, Crown House, 143-147 Regent St., Regent 3891

SUBSCRIPTION RATES
For One, Two, and Three Years

	One Year	Two Years	Three Years
United States, U.S. Possessions and Canada	$ 4.00	$ 7.00	$ 9.00
Latin America and Australia	$ 6.00	$10.00	$14.00
Austria, Belgium, Denmark, France, Great Britain, Holland, Italy, Norway, Portugal, Spain, Sweden, Switzerland and West Germany	10.00	15.00	20.00
All other countries	20.00	30.00	40.00

MEMBER

Audit Bureau of Circulation.

Payments from outside the U. S. A. must be in the form of an International Money Order or check on a U. S. Bank.

Position and company connection as well as products manufactured must be indicated in all subscription orders.

INSTRUMENTS
and
AUTOMATION

Volume 29, No. 3
MARCH 1956

Editorial

Do You Really Know Your Instruments? 457
National Simulation Conference 459

New Feature

Automation Films 432

Feature Articles

Basic Applications of Analog Computers 464
P. J. Hermann, K. H. Starks and J. A. Rudolph

Multiplexing 470
Martin Klein, Frank K. Williams and Harry C. Morgan

Radar and MTI 478
M. H. Aronson, S. I. Sixfin and G. O. Thogersen

Continuous-Anneal-Line Control 483
J. E. Webber

The Digital Ohmmeter 486
C. P. DeWitt

Electronic Circuitry 488
M. H. Aronson and C. F. Kezer

Basic Valve Types and Flow Characteristics 490
C. S. Beard

The Simulation Council Newsletter 507

Journal of the Southern California Meter Association

Maintenance of Mercury-Type Meters 515
Frank D. Welch

Other Regular Features

Letters to the Editor 393
Inquiries 397
Trends 401
Panhandle Pete 411
News 414
Stock Report 428
Events Calendar 430
Biographies of Significance 451
New Instruments 520
Briefs 586
New Literature 600
Searchlight Section 612
Advertisers' Index 614
Inquiry Card 615

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL FOR 28 YEARS — SINCE JANUARY 1928

Instruments and Automation (including Instrument Manufacturing) published monthly by The Instruments Publishing Company, Inc. Offices of publication, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania. Entered as second class matter January 26, 1932, at the post office at Pittsburgh under the act of March 3, 1879. Transferred permit October 14, 1949 to the post office at Pontiac, Illinois, under the act of March 3, 1879.
Copyright 1956.

BIGGER THAN YOU THINK

Skinner solenoid valves are compact, tiny and lightweight. But don't be misled — they'll easily outperform other valves that are much larger and heavier. Built to withstand high voltages and temperature extremes, Skinner valves provide leakproof, trouble-free operation through millions of cycles. And being small, they are easily adaptable to your most compact equipment design. Call in a Skinner engineer on all your valve problems *first*. He can draw from over 100,000 variations . . . all of them *big in capacity, power and performance.*

Write for the new Skinner Solenoid Valve Catalog. On your letterhead, please.

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVE DIVISION • SKINNER CHUCK COMPANY

THE CREST OF QUALITY

116 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

For more information circle **5** on inquiry card.

INSTRUMENTS and AUTOMATION

Letters to the editor

Editor, I&A:

We at Goodyear Aircraft collectively think you have done a very good job (in your editorial "Automation, Revolution and Insight," *I&A*, Feb., 1956) and wish to commend you on your deep understanding of and insight into the role the analog computer should and undoubtedly will play in the future.

We agree that your theme of automation being evolutionary rather than revolutionary is basically sound, and that the computer is revolutionary because it will contribute to and bring into being, when properly utilized, many evolutionary items by fast and efficient development.

We have had nothing but very favorable, enthusiastic comments on the job you have done in this regard. Our Mr. Charles Morrill indicates that you really have your finger on the pulse of the role analog computers should and will play in the general industrial picture of the future. (As you know, Charlie lives considerably further in the future in the realm of analog computers than the average person who is actively engaged in the use thereof.) Our Mr. C. A. Meneley indicates that the editorial was a very strong, hard-hitting punch in favor of analog computers, and that items of this nature can only be beneficial to the computer industry as a whole, as well as to all production industries.

This editorial certainly expresses the feeling I have for the equipment as a basic, necessary tool for successful operations in the future conduct of any business. It is heart-warming to see someone in the publishing industry get off from the slightly hackneyed theme of "magic brain" and "wonder" instruments of the future. Analog computing equipment has a substantial past and most promising present, and should come into its own in the near future—thanks to efforts such as you put forth.

H. P. Partenheimer
Goodyear Aircraft Corporation
Akron, Ohio

We hope so—because of the vast benefits that industry can realize from this development. Our efforts in this direction include our many editorials, our computer articles, the Simulation Council Newsletter, and the Computer Clinics of the Automation Expositions. And the key man in this picture is the instrument engineer in the plant—because he is the man who "best knows the company's products and production process, and who is in position to describe the production process by block diagrams and transfer functions," as P. J. Hermann, K. H. Starks, and J. A. Rudolph (of Goodyear Aircraft) point out on page 464 of this issue.

Editor, I&A:

Our people here are particularly enthused about your series called "Digital Automation."

I want to comment on the "discrete and digital" dicussion in your letters' column on page 5 of the January 1956 issue. Dr. Byers' position is accurate from the standpoint of classic mathematics, but I believe that wide-spread commercial and industrial usage will and should modify his definition of the word "digital."

At the present time the only wide-spread dividing line in the field of data processing occurs at a point we call the digital-analog boundary. I see nothing useful to be gained by trying to find a word like "discrete" to replace present synonymous usage of the word "digital." The important point here is that data processing systems, at present, have two kinds of qualities, and each has its advantages for certain purposes. I do not believe that quantization of input data is either an important or a desirable quality of a data processing system. Actually, if we wish to get technical enough, we can say analog data are also inherently quantized because of our inability to measure current except in integral multiples of one electron. I, therefore, think that any data processing system that involves counting discrete pulses should be called a digital system whether or not the pulses originate from continuous or quantized parameters. *Count* or *scale*: That is the question. Digital components must preserve the count and analog components must preserve the scale accurately. In general, these represent different kinds of components with quite different qualities of linearity, bandwidth, and noise.

I think this topic deserves further discussion because we are going to see a great many additions to the equipment data processing, which will operate on discrete pulses. I do not feel this equipment should be confused with present analog processing equipment in the eyes of the laymen who will be responsible for budget decisions.

I wish to tell you I not only am favorably impressed with the editorial content of *Instruments and Automation*, but also I find advertising and publicity gets a better response from your book than anything else around.

J. N. A. Hawkins
Byron Jackson Division
Borg-Warner Corporation
Los Angeles, California

It looks like a debate on a fundamental point is shaping up here (on the use of "digital"—not on the response to advertising; there is no debate about this latter point)—and it is well to consider these points at this early stage in the development of the data-handling field.

Editor I&A:

I want to state emphatically that the article on the binary system in your November, 1955 issue deserves an award for the best article in 1955. I knew that computers used the binary system, but I never understood how a series of on and off switches could be made to perform complicated mathematics. After I read the article and understood the binary system, it made computers appear both practical and exciting.

My nephew is in the 9th grade and has studied algebra. When I explained the binary system to him, it showed him that the use of mathematics can be fun as well as practical. I'm sure it will stimulate his interest in math, and I would even recommend that the binary, trinary, and other number systems be demonstrated in the teaching of mathematics in our schools. It certainly should stimulate the interest of the students and make the teaching of ordinary mathematics much easier.

In teaching the use of a calculating machine to one of the girls in our office, I attempted to show her how with a radix of 10 the consecutive indices affected each other on the basis of 10 to 1. To make it a little simpler, I showed how using a radix of 2 would make the machines much simpler if our normal number system were a binary system. It really surprised me when I

Analog Computing for One and All

with GAP/R modular components

The Model K2-X Operational Amplifier is an octal-based plug-in unit which nobly serves as nucleus for accurate feed-back computing. With an output of ±100V the K2-X is priced at $24. The K2-W at $20 puts out an ample ±50V with less power needed.

Model K2-P is a Stabilizing Amplifier used in tandem with the K2-W or K2-X. It provides long term DC Stability measured in microvolts. All plug directly into the HK (shown below) or other environments. The K2-P having inherent stability below 0.1 MV is priced at $55.

The Model HK Operational Amplifier in the standard version offers 10 K2-W Amplifiers for analog calculations of infinite variety. A stabilized HK using K2-X and K2-P *"paired"* plug-ins provides greater output plus stability. The *standard* HK with 10 K2-Ws is $360. The *stabilized* HK with 5 of above "pairs" is $555.

Supplied also in a self-powered version as the compact Model HKR Operational Tenfold, all manifolds can be purchased in either *standard* or *stabilized* forms or in other combinations.

For rapid utilization of the HK or HKR, Model K- Modular Assembly units are offered either in kit form or assembled as Adder, Coefficient, Differentiator, Integrator or Unit-lag Passive Operational Plug-ins. Prices furnished on request.

One of the many "power packages" from GAP/R is the Model R-100 Regulated Power Supply, conservatively rated at 100 ma, ±300VDC, and modestly priced at $130.

Indicated below are two possible arrangements whereby your laboratory or engineering office can obtain a basic computing facility at minimum cost.

20 OPERATIONAL AMPLIFIERS Plus Regulated Power		10 STABILIZED AMPLIFIERS Plus Regulated Power	
2 HKs (with 20 K2-Ws)	$720.	2 HKs (10X's + 10 P's)	$1110.
1 R-100 Power Supply	130.	2 R-100 Power Supplies	260.
	$850.		$1370.

For more details and other information please write to:

George A. Philbrick Researches, Inc.
230 Congress Street, Boston 10, Massachusetts

GAP/R

For more information circle 6 on inquiry card.

LETTERS—CONTINUED

saw the look of comprehension that was shown on the face of this girl.

Instruments and Automation is certainly maintaining its position as foremost in the field.

P. M. Hankison
Hankison Corporation
951 Banksville Road
Pittsburgh 16, *Pa.*

Thus does basic education spread horizontally and vertically, through plants and offices, to nephews and secretaries. One of deep satisfactions in life is learning a new fact or principle—an equally deep one is teaching the principle.

Editor, I&A:

I have just read your editorial comments on "Automation and Economics" and "Automation and Culture." Both of them are beautifully done: forceful, simple, persuasive. Congratulations!

Irving Murray
Minister, First Unitarian Church
Pittsburgh 13, *Pa.*

The First Unitarian Church of Pittsburgh has held a series of Sunday-morning roundtable group discussions on "Automation and its Impact on Our Future."

Editor, I&A:

Your recent editorial on Automation entitled 'A Counterattack on Anti-Automation Propaganda,' which appeared in the June edition of *Instruments & Automation* was one which I think merits praise . . . what you put into that editorial certainly looked like clear thinking to me.

Not so long ago, the president of the company for which I work came to Sarnia with the director for an annual gathering of Sarnia employees. In his brief remarks prior to the social part of the evening, he found it necessary to refer to automation, and to assure the audience that "automation does not eliminate jobs, it creates them." I am afraid that some of the people there might not be entirely convinced, especially when a piece appeared in the local newspaper a short time later, to the effect that another company in Sarnia which employed more than 400 men before a layoff (caused by a strike in another company to which they supplied parts), recalled only 260 or so after the lay off, and this was due to the 'installation of new automatic equipment (automation)'. I have saved a copy of the article for future reference.

Could I kindly have your permission to use your definition for automation, and possibly include other extracts from your editorial? It would help me considerably if I could do this because I would prefer to follow the line of thinking of someone such as yourself who knows what he is talking about.

J. R. Connell (P. E.)
Sarnia, N. Y.

If our ideas have real merits (and we hope they do) the constructive thing is to use them wherever and whenever possible. You and all our readers have our permission for any use you want to make of our editorial ideas, with or without credit to us. And thanks for your truly kind comments.

Editor, I&A:

May I congratulate you on your editorial "Automation and Culture" in your August issue: I thought your presentation both clear and strong.

The purpose of the editorial has me confused and therefore suspicious. The point of view expressed is so unpopular to your main audience (electronic and instrument engineers) that I'm inclined to believe that it was written to attract attention or start arguments . . . To fuel suspicion is the fact that there is little of moral or cultural value, strictly speaking, within the contents of your publication. It is—so far as its material is concerned—what it is valued and read avidly for—a good, practical down-to-earth instruments magazine.

James J. Pollard
Manning, Maxwell & Moore, Inc.

No, the purpose was not to start arguments—it was simply to speak out (as clearly and strongly as possible) on an issue we felt to be even more important than the many technical things we might have discussed that month. As to conforming to "popular opinion," your editors go on record as favoring free and open discussion of all ideas (including the unpopular and heretical) in any field. As to more cultural material, maybe we should have a column on "Poetry for the Instrument Engineer." Contributions are awaited!

New ASCO 3-Way Solenoid Valve assures MILLIONS OF TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

The EXTRA HEAVY FORGED BRASS BODY houses only three moving parts: Two diaphragms and a core. Corrosion protection is assured. All parts in contact with fluids or gases are brass, stainless steel or Buna-N.

SIMPLICITY IN OPERATION

Not only its construction but also its new operating principle is the essence of simplicity: solenoid piloting of two simple diaphragms.

UP TO 400 CYCLES PER MINUTE

Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

CONVERTS IN 30 SECONDS

Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in ⅜″ and ½″ pipe sizes, both with full ⅝″ orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

ASCO

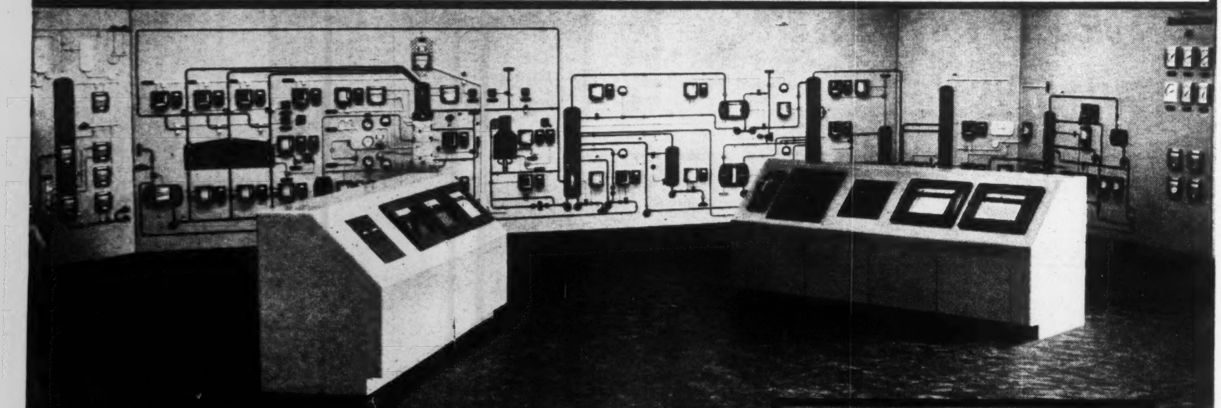
DEPENDABLE CONTROL

AUTOMATIC SWITCH COMPANY • 385T LAKESIDE AVENUE • ORANGE, NEW JERSEY

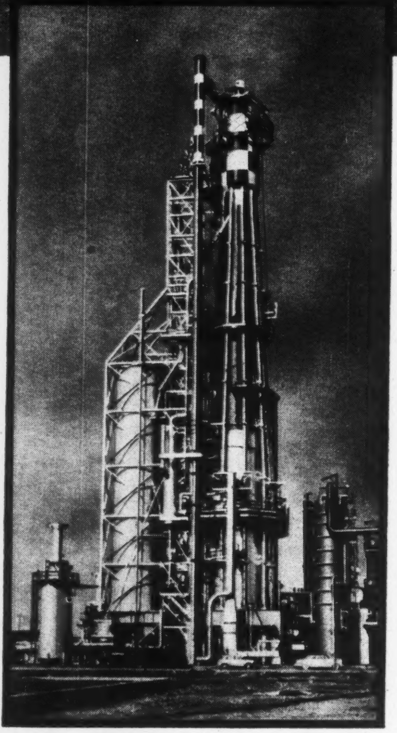
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

For more information circle **7** on inquiry card.

"American-Microsen" Electronic Control chosen by PETROFINA on proved performance



Photos courtesy The Lummus Company, New York, N. Y. and
Canadian Petrofina Ltd., Montreal, P. Q.



This is the new refinery of Canadian Petrofina, Ltd., at Point aux Trembles, Quebec. Located here is the first Catalytic Cracking Unit in the Western Hemisphere to be operated by the "American-Microsen" Electronic Process Control System. It is the latest of hundreds of installations that have proved the reliability and practical advantages of "American-Microsen" control for refineries and chemical plants.

This Petrofina installation demanded long-distance transmission and difficult control applications, but start-up was completed ahead of schedule—to the benefit of refinery and contractor. *And the installed cost of the instruments was the same as for conventional controls.*

The long list of successful "American-Microsen" applications includes plant-scale operation of numerous critical petroleum and chemical processes. Conventional instruments could not control some of these processes, but they are handled easily by "American-Microsen" because of its speed of response, sensitivity and lag-free transmission. Many of these installations have been functioning well over a year, without maintenance problems, and with the enthusiastic approval of users.

You want better control and simplified servicing in automating your processes for higher product quality and greater economy. The "American-Microsen" Electronic Process Control System assures both—on new units and those now impossible to control satisfactorily. Invite one of our field sales engineers to help you determine the best equipment for your requirements without obligation, of course.

MANNING, MAXWELL & MOORE, INC.

MAXWELL
M&M
MANNING & MOORE INC
TRADE MARK

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO
PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

For more information circle **8** on inquiry card.

INSTRUMENTS and AUTOMATION Inquiries

The inquiries below were received from subscribers to **Instruments and Automation. In most** instances an answer has been sent, but we shall be glad to forward the name and address of the inquirer if you have any further suggestions.

Specific Gravity Measurement

Electronic Equipment manufacturer seeks instrument for measuring specific gravity that uses "tuning fork method." A-49

Dial Switch

Telephone dial type of switch is being sought for new unit being developed by firm. A-50

Controlled Volume Pump

Physicist with agricultural research activity seeks water pump to deliver steady flow of one gallon per hour at 50-100 psi. Unit should be light, compact and operate from 110-v, 60-cycle power source. Water is supplied at atmospheric pressure. A-51

Lead Sulfide Photoelectric Cells

Engineer of large Italian instrument manufacturing company seeks U. S. source of lead sulfide photoelectric cells. A-52

Thin-sheet Coiling Control

Reader seeks control to maintain true roll-winding of 0.008" CRS sheets moving at 40 in/min. A-53

Fractional HP Torque Measurement

Engineer with large manufacturer of automotive and electronics equipment seeks test equipment to measure torque of fractional-horsepower d-c motors. A-54

Electromagnetic Oscillographs

Importer in Japan seeks 10- or 12-channel "electromagnetic oscillographs" for client. A-55

Lint Measurement

Reader (Manager of Tube Division of large electronics firm) seeks device for rapid measurement of lint concentration in the atmosphere. A-56

Servo Loop Demonstrator

Engineer with large electronics firm seeks kit for breadboard demonstration and try-out of small electromechanical servo loops, both synchro and resolver controlled. A-57

Differential Transformer

Scientific instrument manufacturer seeks address of the Crescent Engineering Company (New York State) as source of small differential transformers. A-58

Phase-Sensitive Voltmeter

Swedish reader seeks manufacturer of "phase-sensitive voltmeters." A-59

Wire Tension Indicator

Belgian lamp and electronics concern seeks suppliers of tension meter or tension tester for coiling copper wire on coiling machine. Diameters range from 0.1 to 0.5 mm; tension from 3 to 12 kg/mm^2. A-60

Merchandise Control

Consultant seeks information or firms specializing in electronic impulse-type circuits for merchandise handling, including assembling, orders (warehouse orders, production orders, retail sales orders, etc.), inventory control, sales, packaging, etc. Also seeks names of firms desiring such equipment. A-61

Thermal Transducers

Research and development department seeks manufacturers of thermal transducers . . . . "apparatus designed to measure heat flow, consisting basically of a block of material and system of thermocouples." A-62

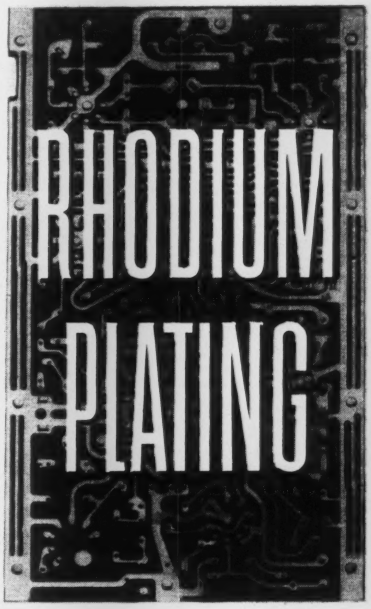
Welding Analysis

Engineer with large manufacturer seeks "instrument for measuring arc energy in a pair of switch contacts, by registering the product of arc current and arc voltage. Interested in measurements over current range 0-20 amperes and voltage range 0-250 volts d-c. Output should be readable against time base on oscillograph or readable as an integrated value on a meter." A-63

Phonograph-type Tape Recorders

Research and development department manager seeks source of phonograph-type tape recorders—that is, recording using phonograph principle to record on plastic tape similar to 16 mm film. A-64

PROTECT PRINTED CIRCUITS AGAINST CORROSION...



Rhodium over nickel, or over silver in printed circuits—is only one of the many invaluable applications of Rhodium in electrical and electronic products. It improves performance wherever a low resistance, oxide-free contact is desired. Rhodium plate assures low noise level for moving contacts, low and stable contact resistance . . . and amazingly long wear.

For complete details send for free booklet on "Rhodium Plating" and its advantages.

ELECTROPLATING with RHODIUM

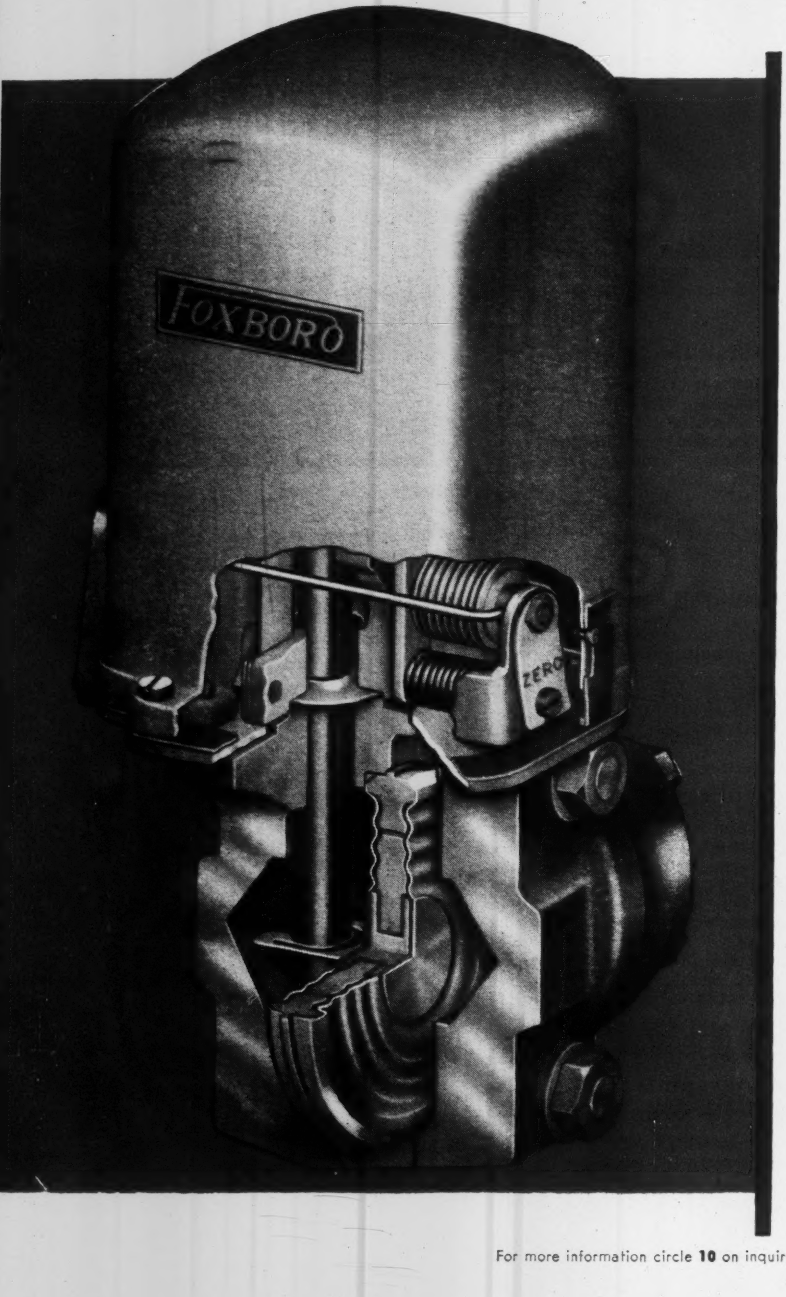
BAKER & COMPANY INC PRECIOUS METALS

113 ASTOR STREET, NEWARK 5, N. J.
NEW YORK • CHICAGO
SAN FRANCISCO • LOS ANGELES

ENGELHARD INDUSTRIES

For more information circle 9 on inquiry card.

ONLY the Type 13A d/p
has these 6 advanced-



- **Positive Overrange Protectio**
  up to full 1500 lb. rating
- **Fully Adjustable Ranges . . .**
  0-20" to 0-80" and 0-50" to 0-250" H_2O differential
- **Automatic Internal Dampin**
  . . . fast, *stable* measurement
- **Simplicity** . . . easiest, lowest cost installation, least maintenance
- **Convenient Zero Adjustment**
  . . . external — no need to remove weatherproof cover
- **Highest Sustained Accurac**
  . . . even under extreme operating and ambient conditions

With these basic features, plus many other technical refinements throughout, the new Type 13A d/p Cell* Transmitter surpasses all previous records in performance . . . economy . . . convenience. For the complete story and a demonstration, call your nearest Foxboro representative. Write for new Bulletin 13-1. The Foxboro Company, 463 Neponset Ave., Foxboro, Mass., U.S.A. Factories in the United States, Canada and England.

*Reg. U. S. Pat. Off.

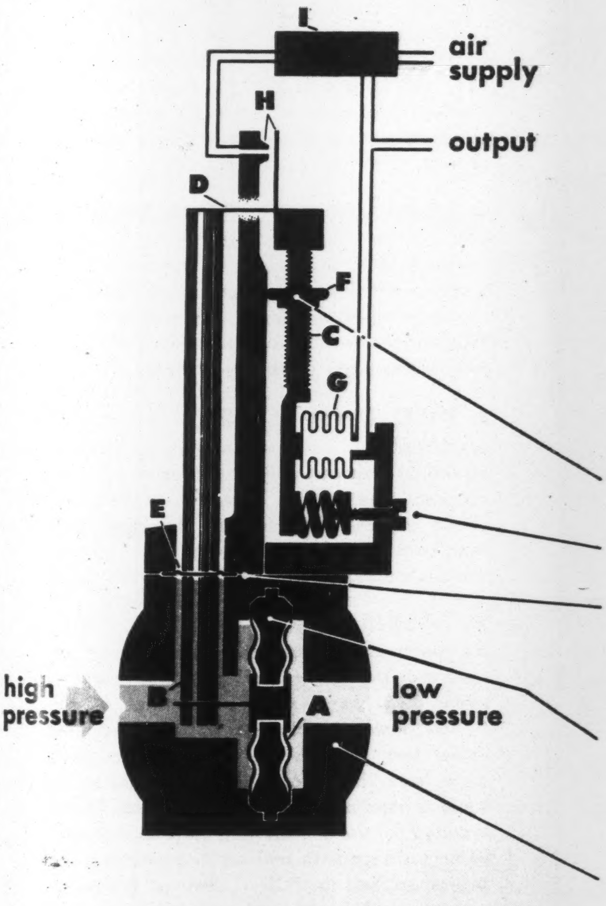
More Foxboro flow transmitters are in use by the process industries than all other makes combined!

For more information circle **10** on inquiry card.

hig
pre

Cell Flow Transmitter

– design features...



How It Works . . .

An increase in differential pressure across Twin-Diaphragm Capsule (A) exerts force to right on force bar (B). Elgiloy® diaphragm seal (E) acts as fulcrum. Force to left at top of bar (B) causes flapper to approach nozzle at (H). Resulting increase in nozzle pressure is amplified by relay (I). This pressure is sent to feedback bellows (G) which develops force to counterbalance the differential pressure on capsule (A). The 3-15 psi output signal from relay (I), always precisely proportional to differential pressure, is transmitted to remote recording or controlling instrument.

Range Wheel is continuously and easily adjustable for entire range whether 0-20" to 0-80" or 0-50" to 0-250" H_2O.

Easy-access screw adjustment permits field "zeroing" without removing weatherproof cover.

Elgiloy® stainless alloy diaphragm seal assures a corrosion-resistant, frictionless, positive pivot point. Instrument is constructed in 3 basic units — body, transmitter, and air relay block — eliminating all possibility of errors produced by piping stresses.

Silicone-filled Twin-Diaphragm Capsule filters out flow disturbances ("noise") at measurement source . . . without loss of speed of response. Precisely matched surfaces of diaphragms and capsule core provide "stops" which give positive overrange protection in both directions.

Rugged forged body, optionally Type 316 S.S. or carbon steel, gives greatest strength with least weight . . . ultra-compact design permits low cost mounting from flange taps.

FOXBORO
Reg. U.S. Pat. Off.

First in Flow Instrumentation

For more information circle **10** on inquiry card.

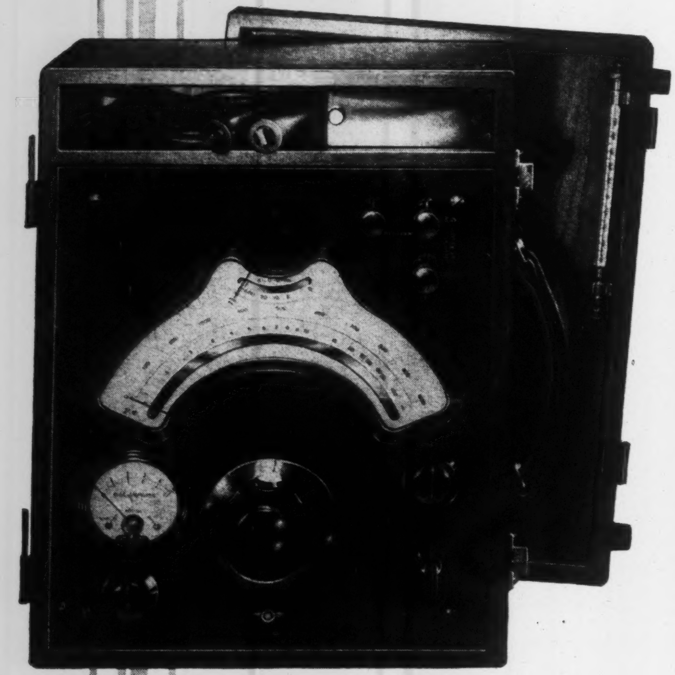
AN ACCURATE, PORTABLE, MULTI-FUNCTION INSTRUMENT

THE LEWIS *PORTABLE* TEST POTENTIOMETER

for Service Testing Exhaust Temperature Measuring Systems

Developed for use by field service engineers of a leading engine manufacturer, the Model 13P05 Test Potentiometer has proven its serviceability in desert heat and arctic cold at maintenance bases on many points of the globe.

FOUR PRECISION INSTRUMENTS IN ONE!



Model 13P05

For dependable maintenance, use test equipment made by the manufacturer of the components to be checked.

A PYROMETER-POTENTIOMETER

for measuring exhaust thermocouple temperatures that is truly portable with a sturdy pivoted galvanometer and without a standard cell. Accurate automatic electrically operated cold junction compensation permits this instrument to be used in ambient temperatures from below freezing to plus 120°F. Mirror scales with precise hand-drawn graduations and knife edge pointers insure accurate readings from zero to 1000 degrees Centigrade.

A LOW RANGE OHM-METER

with a widely spaced, hand drawn scale for checking the resistance of leads, thermocouples and balancing resistors to insure correct adjustment to match external resistance requirements of exhaust temperature indicators, either eight or twenty-two ohms.

A KILO-OHM METER,

energized by a 67½ volt battery for checking insulation resistance of lead-wires and thermocouples. Due to the potential applied, this circuit is more effective in detecting flaws than conventional ohm meters. A hand-drawn scale is clearly marked in kilo ohms resistance.

A THERMOMETER TESTER

for precise scale error checks of exhaust temperature indicators having either eight or twenty-two ohms external resistance. A controlled power supply energizes the indicator under test, through the correct series resistance, and the zero to 1000°C temperature scale is used as a reference standard. Recommended for use in adjusting exhaust indicators in accordance with ambient temperature, with power applied for 700°C, through the proper resistance. A liquid-in-glass thermometer and flexible test leads are supplied with each instrument.

LEWIS ENGINEERING CO.

NAUGATUCK, CONNECTICUT

For more information circle 11 on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Clerical help has increased from 11% of the total work force in 1940 to 16% in 1955; $1 billion was spent in 1955 for office machinery—yet total number of clerks increased in 1955 by 200,000, says S. A. Allyn, president, The National Cash Register Co. Office automation equipment is needed to meet inadequacy of labor force in both numbers and handling of ever-increasing volume of paper work.

About 11 research reactors are now in operation in USA. Power levels range from 10 watts to 40,000 kw. AEC plans 2 more in immediate future—at ORNL (Oak Ridge) and NRTS (Idaho). Twelve research reactors are in operation abroad—2 in England, 2 in Canada, 3 in Russia, 2 in France, 1 in Norway, Sweden and Switzerland. Twelve more are planned abroad.

Trend to automation in the $2½ billion hotel industry is underway on 3 fronts, says W. T. Gove of M-H Regulator Co., Phila.—(1) mechanical area of heat, light, power and refrigeration, which totals about 10% of room sales and 4% of total income, (2) business area of automatic office and registration techniques, including room assignments, mail handling, charges, bills, etc., and (3) guest area, including room temperature control, remote radio and TV control, messages, light and door control, news, etc.

Watch for exciting control valve developments from nuclear power field. Valves have been designed for tight shut off in service never before possible.

Increased use of higher voltages for distribution on Rural Electrification Administration electric systems is predicted on basis of 7-year experience with 14.4/24.9 kv lines, which has been adopted as a standard REA voltage. Although over-all cost is 20% higher than 7.2/12.5 kv systems, cost per kv capacity is only 1/3 that of the lower-voltage system because line capacity is quadrupled.

Mallory mercury cell with stabilization can compete with standard cell as source of calibrating emf.

Total USA railway mileage exceeds 220,000; 35,000 locomotives are in use. In the 10 years since VHF communication (r-f and inductive carrier) was authorized, about 16,800 transmitters have been authorized; about 10,000 are in operation. Number of authorizations has doubled in last two years. More than 70,000 units would be required to fully equip the locomotives, the 25,000 cabooses, and right-of-way stations. Improved communications have saved $100 million annually, says R. G. May, V.P. of Assoc. of American Railroads. Emphasis is shifting from classification yards to main line communications.

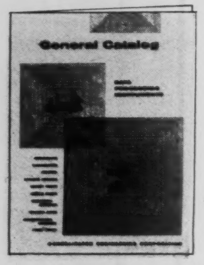
there's a CEC instrument for your data-recording problem

Small problem, like tracking down vibration in a tractor seat? Or big problem, such as flight testing a new intercontinental bomber? *Whatever* your testing problem, count on CEC for your data-recording instrumentation. Consolidated offers the one *complete* line of data-recording instruments and systems . . . and its scope and versatility have never been matched.

Use *any* CEC oscillograph with *any* CEC amplifier or bridge balance. All are compatible . . . no modifications are required. Keystone of this flexibility is CEC's 7-300 Galvanometer (right), the "design nucleus" for all CEC analog data-processing instruments. Extremely stable . . . rugged . . . available in a wide range of characteristics (e.g. response from 0 to 3000 cps), it brings laboratory accuracy to on-the-spot oscillograph recording.

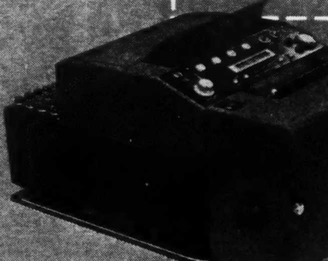
NATION-WIDE SERVICE

. . . an important ingredient of all CEC instruments is an intangible . . . SERVICE. Experienced, factory-trained service engineers stationed at CEC field offices throughout the United States are available for both emergency repairs and regularly scheduled maintenance calls. They are your assurance of uninterrupted test programs, regardless of where you are located.



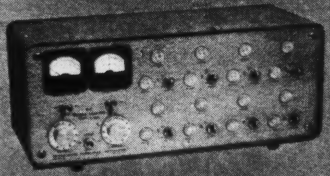
For a more detailed resumé of CEC's analog data-recording instrument line, send today for your copy of Bulletin CEC 1301-X 16.

Recording



TYPE 5-119 . . . latest, most advanced CEC oscillograph. Records up to 36 or 50 data channels on 12″ x 250-ft. records at speeds from 0.1 to 100 inches per second, with built-in provision for *instant* 10:1 speed change. All controls on a single panel, with unique warning and safety devices to insure against malfunction and loss of vital, irreplaceable test data.

Bridge Balances &



TYPE 8-108 BRIDGE BALANCE *(shown above)* . . . allows direct coupling of recording oscillograph to as many as 8 channels of strain gages or other resistive-type pickups. Each channel has separate balancing and input excitation-voltage adjustments, and a selector switch provides a sequence of 10 built-in calibration-signal values.

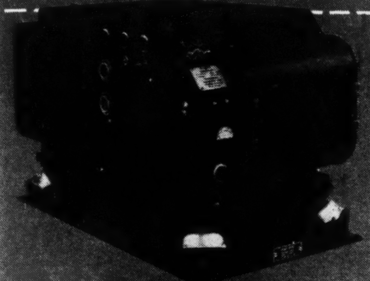
TYPE 8-110 BRIDGE BALANCE . . . 4-channel control link between oscillograph and strain gages or resistance-type pickups. Contains controls for balancing and adjusting d-c voltage across each channel and provision for connecting an external calibration resistor.

Consolidated

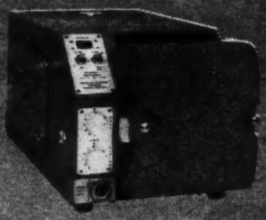
ELECTRONIC INSTRUMENTS
FOR MEASUREMENT AND CONTROL

For more information circle **12** on inquiry card.

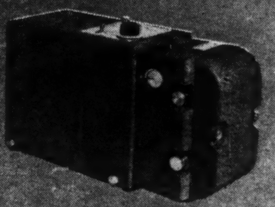
Oscillographs *from 6 to 50 channels . . .*



TYPE 5-114 . . . practically the "standard oscillograph of the world" . . . the most widely used, most versatile instrument of its type in existence. Records either 18 or 26 traces on 7" paper or film. High-speed accessory magazines permit record speeds as *high as 500" per second* . . . records as long as 250 ft. or 600 ft. Can be used anywhere . . . in laboratories, in vehicles or in flight.

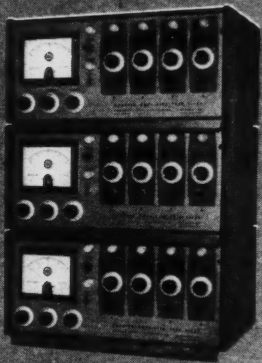


TYPE 5-116 . . . an excellent general-purpose oscillograph offered with 14 data channels. Records on 5-inch-wide paper or film at 10 speeds from ¼" to 100" per second. Automatic record numbering, 1/100-second timing lines, easy-load magazine and trace identification. Rugged enough for the most extreme environmental conditions.



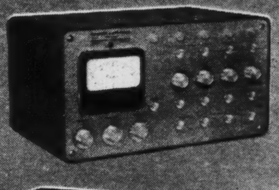
TYPE 5-117 . . . records up to 6 channels of data *without amplifiers* at frequencies to 200 cps (with amplifiers, to 3000 cps). Uses 70-mm by 100-ft. paper or film, driven ¾" to 24"/second. Timing lines appear every 1/100 second. A new high in flexibility, a new low in cost, the 5-117 fills the gap between pen-type recorders and advanced oscillograph/amplifier systems.

Amplifiers *for any test condition*

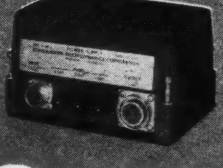


TYPE 1-127 CARRIER AMPLIFIER *(shown stacked, top right)* . . . completely self-contained, 4-channel, 20-KC unit usable with either resistance or reluctance-type pickups. Its outstanding frequency response . . . *flat from 0 to 3000 cps* . . . makes it ideal for blast and rocket studies.

SYSTEM D . . . one of the most useful of all amplifier systems, accommodating up to 12 channels of interchangeable 3-KC carrier and 5-5000 cps linear/integrating plug-in amplifiers. Usable with self-generating and modulation-type pickups in laboratory, mobile or flight testing.



TYPE 1-118 CARRIER AMPLIFIER *(shown center, right)* . . . 4-channel, 3-KC, economical self-contained unit for strain-gage work from 0 to 600 cps. Unusually convenient control and calibration provisions.



POWER SUPPLIES . . . CEC offers a number of power supplies designed to increase the flexibility of its amplifiers and oscillographs. Models are available for conversion of 26 volts d-c to 115 volts a-c . . . 115 volts a-c to 26 volts d-c . . . and 400-cycle a-c to 26 volts d-c (shown bottom, right) . . . other power supplies are offered for supplying closely regulated excitation voltage to strain gages and other resistance-type pickups.

Electrodynamics Corporation

formerly Consolidated Engineering Corporation

300 North Sierra Madre Villa, Pasadena, California—SALES AND SERVICE OFFICES IN: *Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D.C.*

For more information circle **12** on inquiry card.

FISHER®

Design Engineering and
Development Department

Research Laboratory
Test Equipment

Flow Testing Section for
Capacity and Performanc

For more information circle **13** on inquiry card.

to Serve You Better...

Fisher Governor Company has built the industry's most modern and completely equipped engineering, research and administration building.

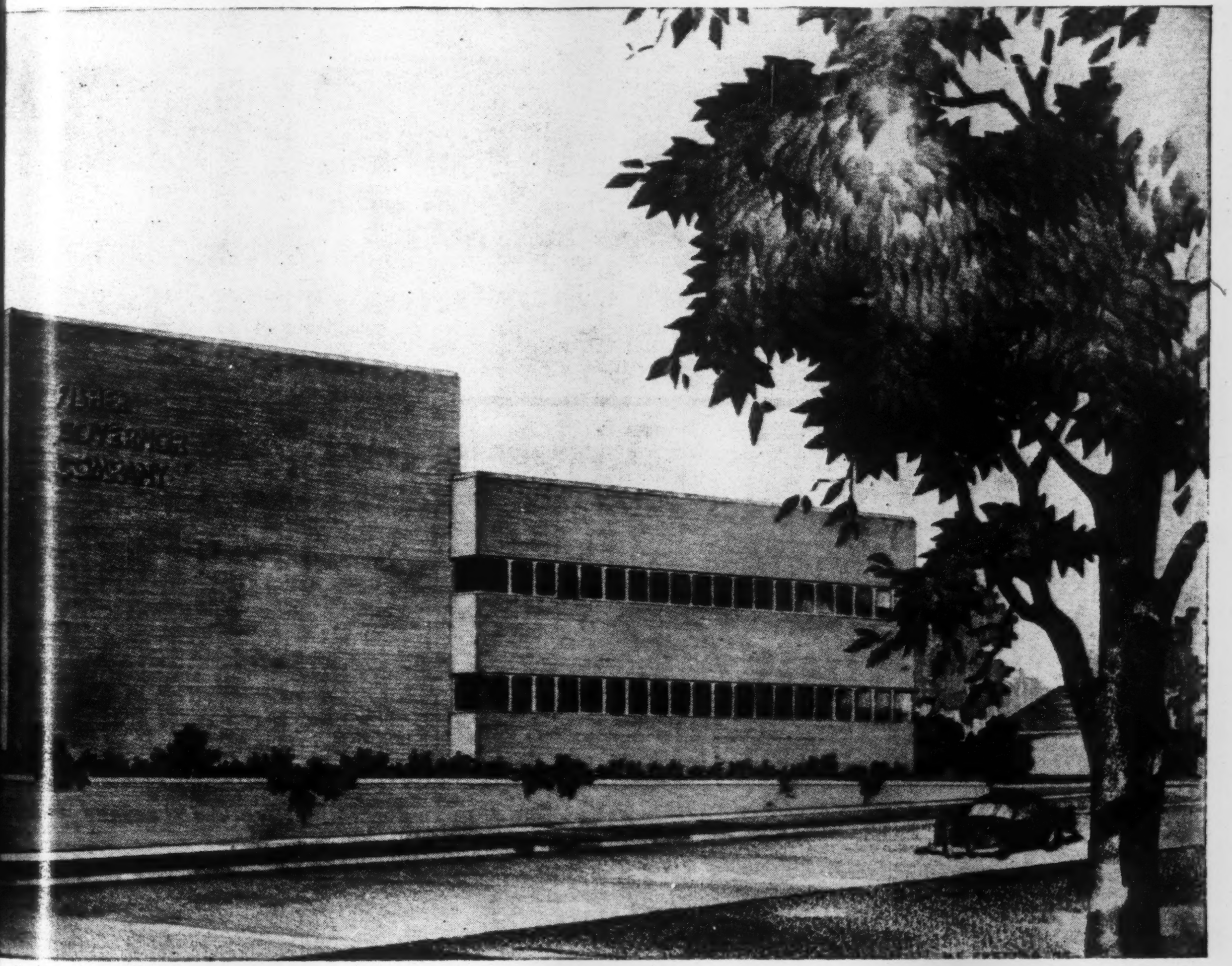
These new facilities—occupying over 100,000 square feet of space—make possible better coordination and greatly expanded engineering and research activities, so as to provide you the world's finest automatic control equipment. A series of test lines up to 12″ diameter are located in the research laboratory. Performance tests are run on Fisher products at pressures up to 2500 psi, using air or water as flowing medium.

The enlarged product engineering department is located adjacent to the research laboratory area. Sales engineering and administrative offices are also in the new building.

FISHER GOVERNOR COMPANY • MARSHALLTOWN, IOWA

CANADIAN PLANT: WOODSTOCK, ONTARIO

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL



For more information circle **13** on inquiry card.

CLIFTON PRECISION'S NEW SIZE 8 SYNCHROS

ACTUAL SIZE
Available in all Types!
1.240"
.750"

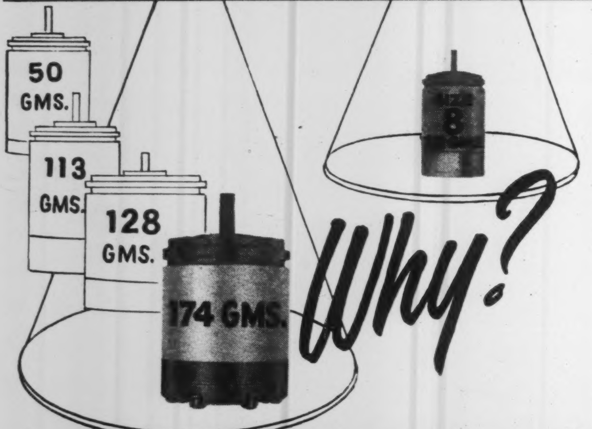
ACCURACY 7 MINUTES · WEIGHT 32 GMS.

Function	Type Number	Primary Element	Excitation Voltage 400 cy.	Input Current (ma.)	Input Power (Watts)	Primary Impedance Secondary Open (Phase)	Primary Resistance (line)	Secondary Element	Output Voltage	Secondary Impedance Primary Open (Phase)	Secondary Impedance Primary Shorted	Secondary Resistance (line)	Phase Shift Degrees	Sensitivity mv./deg.	Accuracy Minutes Max.
Transmitter	CGC-8-A-7	Rotor 1 Phase	26.0	100	.50	54+ j260	37.0	Stator 3 Phase	11.8	12+ j45	15+ j3.5	11.8	8.0	200	7
Control Transformer	CTC-8-A-1	Stator 3 Phase	11.8	90	.23	28+ j110	24.7	Rotor 1 Phase	23.6	220+ j740	246+ j60	143	8.5	400	7
Control Transformer	CTC-8-A-4	Stator 3 Phase	11.8	37	.09	67+ j270	59.5	Rotor 1 Phase	24.0	508+ j1680	640+ j190	381	9.2	400	7
Resolver	CSC-8-A-1	Stator 2 Phase	11.8	84	.27	38+ j136	27.0	Rotor 2 Phase	23.2	280+ j600	344+ j75	230	11	400	7
		Rotor 2 Phase	26.0	39	.43	280+ j600	230	Stator 2 Phase	10.6	38+ j136	70+ j29	27.0	20	180	7
Repeater	CRC-8-A-1	Rotor 1 Phase	26.0	100	.50	54+ j260	37.0	Stator 3 Phase	11.8	12+ j45	15+ j3.5	11.8	8.0	200	30*
Differential	CDC-8-A-1	Stator 3 Phase	11.8	85	.21	27+ j120	25.0	Rotor 3 Phase	11.8	38+ j122	47+ j14	36.0	9.0	200	7 Rotor 7 Stator

Total Null max. 30mv for each unit

Also available in 115v 400cy primary, 90v secondary Transmitters, C.T.'s, Receivers

*Torque 2400 mg.-mm./degree from CGC-8-A-7


50 GMS.
113 GMS.
128 GMS.
174 GMS.
SIZE 8
Why?

WHY USE 1945 SYNCHROS IN 1956 DESIGNS?

Clifton's new Size 8's can take the place of larger units at very significant saving in bulk and *weight*.

These new Size 8's are now in use in some of the latest and *lightest* avionic equipment. In equipment which must be flown, why load on extra weight?

Samples are available from stock, quantities from the production line.

VISIT OUR EXHIBIT, BELMONT PLAZA HOTEL

I.R.E. Convention, New York City, March 19-22

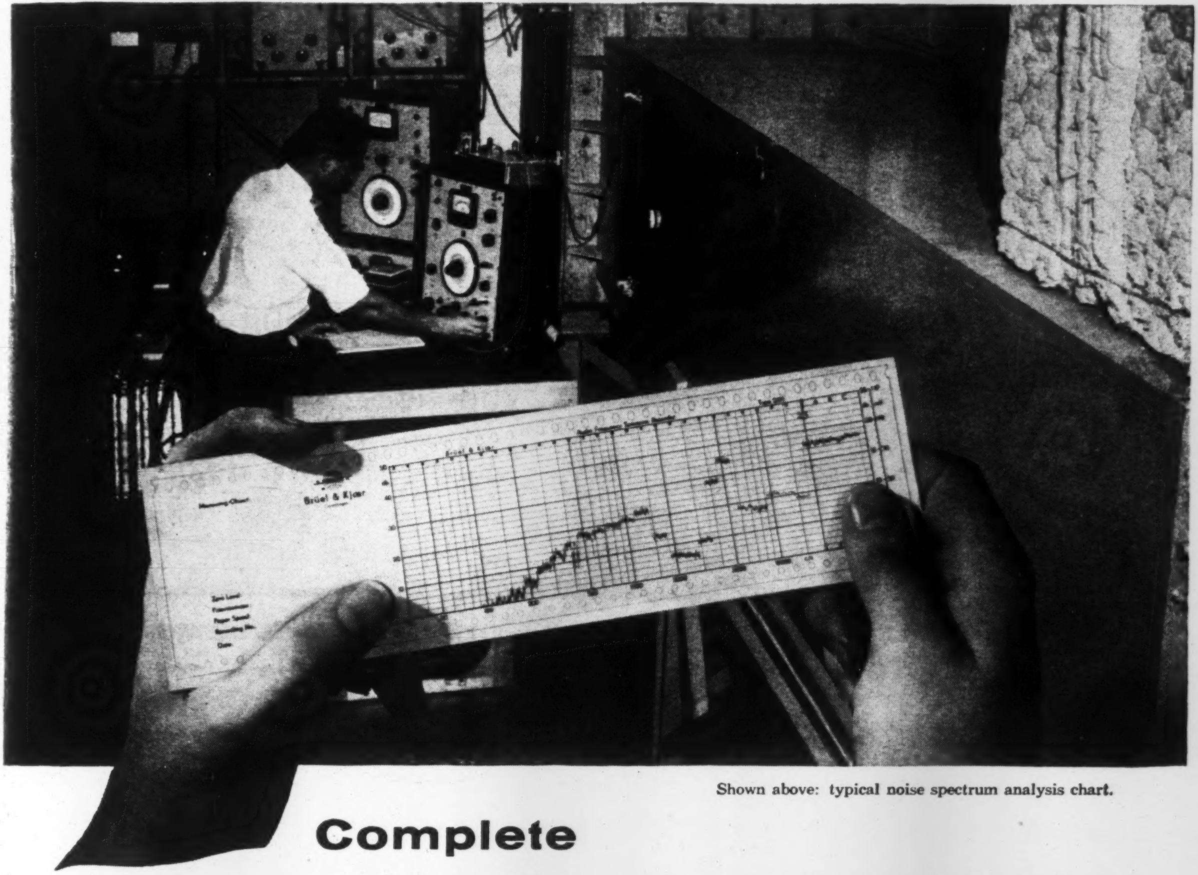
LOOK TO CPPC FOR **cppc** *SYNCHRO PROGRESS*

CLIFTON PRECISION PRODUCTS COMPANY, INC.

CLIFTON HEIGHTS PENNSYLVANIA

For more information circle **14** on inquiry card.

BRUSH . . . *complete systems for noise or vibration measurement*



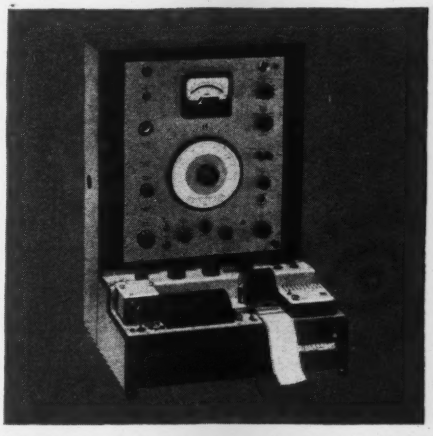
Shown above: typical noise spectrum analysis chart.

Complete frequency-amplitude noise record helps Lockheed design quieter aircraft

This test at Lockheed Aircraft measures the loss in acoustic transmission through fuselage wall panels. To design for noise reduction, engineers needed *complete* data, selected the Brush Spectrum Recorder for these advantages:

- **Recorder automatically scans and records sounds from 35 cycles to 18,000 cycles per second *automatically* eliminating laborious recording.**
- **Measurements made in one-third octave steps, to positively identify frequencies.**
- **Complete recording through the audible frequency range takes only 18 seconds, to save valuable engineering time.**

For noise or vibration analysis, Brush offers the outstanding line of instrumentation available. It's a *complete* line, thus units are matched, and we can offer application assistance on the complete project. For bulletin on this instrumentation write Brush Electronics Company, Dept. A-33, 3405 Perkins Avenue, Cleveland 14, Ohio.



Third-octave Spectrum Recorder, key instrument in a complete line for noise and vibration measurements.

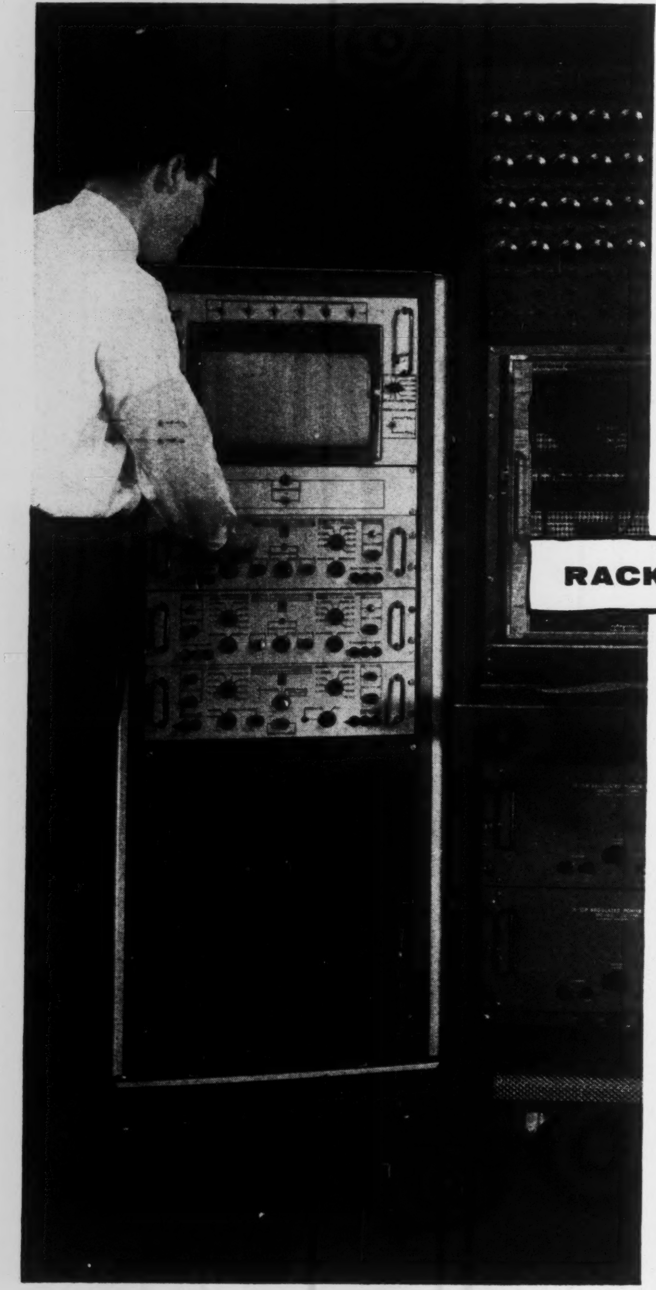
BRUSH ELECTRONICS BRUSH ELECTRONICS **COMPANY**

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

Division of
Clevite Corporation

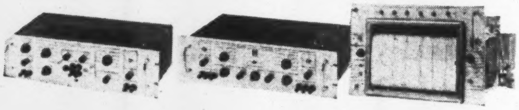
For more information circle **15** on inquiry card.

HOW TO SPEED YOUR TESTING



Complete line of
BRUSH RECORDING SYSTEMS
offers exact
instrumentation
you need to record data
faster... more easily

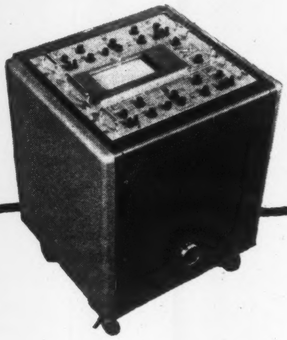
RACK-MOUNTED SYSTEMS



Oscillographs and amplifiers fit standard 19-inch racks. For 1, 2, 4 or 6-channel systems.

MOBILE INSTRUMENT CART

Single or dual-channel oscillograph with accompanying amplifiers may be mounted in this mobile instrument cart. "Instrumentation on wheels" saves engineers' time.



For more information circle **16** on inquiry card.

AND DEVELOPMENT

These direct-writing oscillographic systems record variables from d.c. to 100 cycles per second immediately, eliminate the manual labor in data recording.

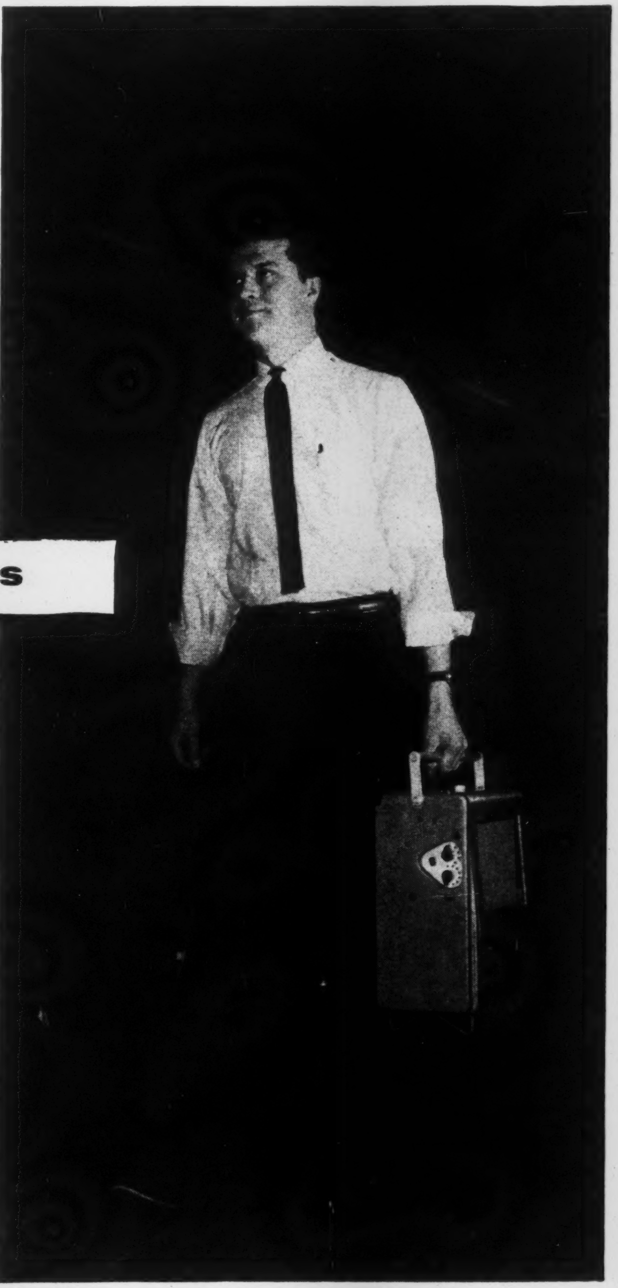
Only Brush offers all these features:

WIDE SPEED SELECTION . . . choice of 8 or 16 chart speeds allows you to select the speed best suited for the variable being measured, assuring optimum readability, accuracy and economy in chart paper.

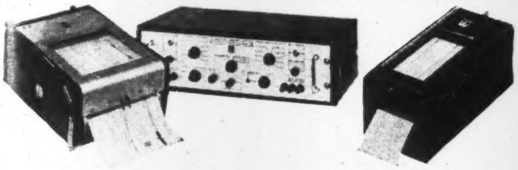
EASILY OPERATED . . . set-up time is at a minimum. Instantaneous switching and remote control streamline operation.

COMPLETE LINE . . . Brush Systems are complete. You have a choice of D.C. Amplifiers, amplifiers for use with either resistive or inductive transducers, or high gain amplifiers. Choice of ink or combination ink and electric writing oscillographs.

GET THE FACTS . . . Ask your Brush Representative for complete specifications, or write Brush Electronics Company, Department A-3, 3405 Perkins Avenue, Cleveland 14, Ohio.



PORTABLE SYSTEMS



Portable oscillographs and amplifiers are light in weight, easy to set up on the job. Four channel oscillograph weighs 38 pounds, 6-channel unit 51 pounds.

IDEAL FOR FIELD USE

Portable units are rugged, designed to stand up under tough field testing conditions, yet perform with laboratory accuracy. Brush equipment is ideal for instrumentation set-up in station wagon, trailer, etc.

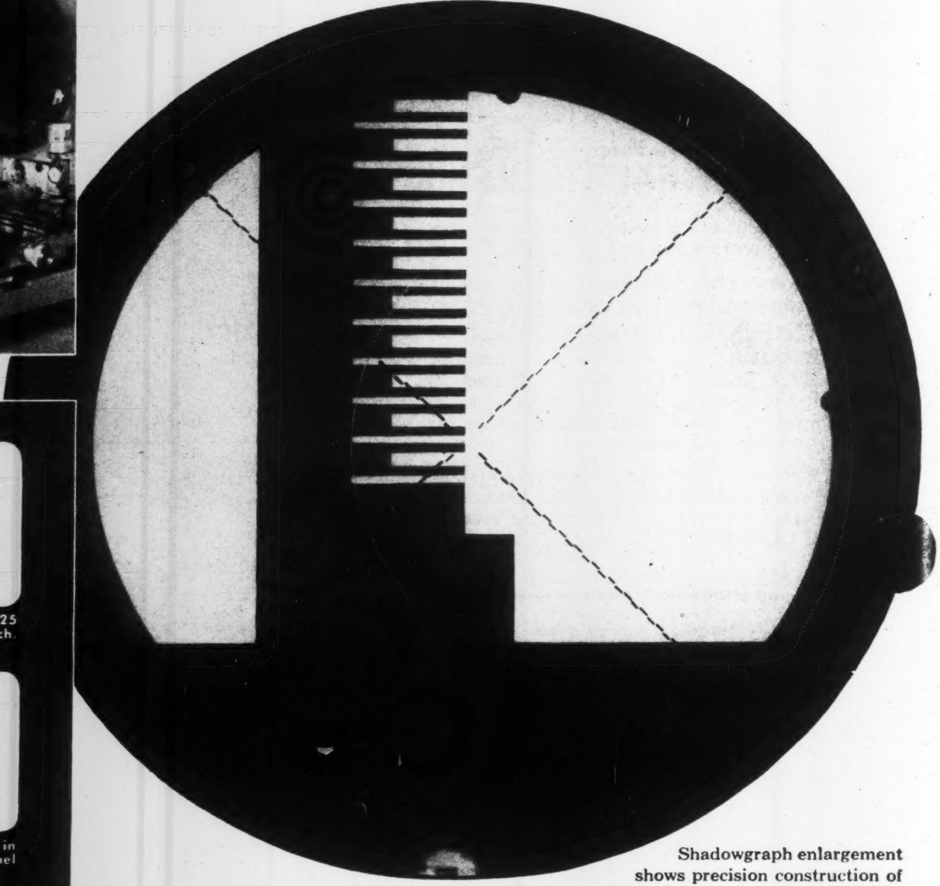
BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

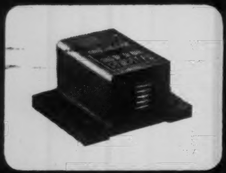
Division of
Clevite Corporation

For more information circle **16** on inquiry card.

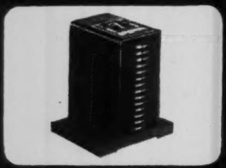
Brush Magnetic Heads



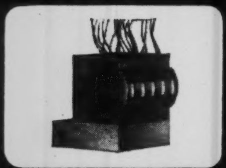
Shadowgraph enlargement
shows precision construction of
magnetic head with 13 channels per inch.



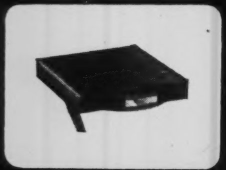
BK-1300 series—up to 25 interlaced channels per inch.



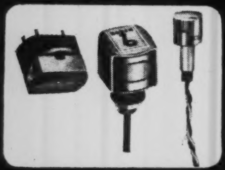
BK-1500 series—ultimate in precision-made multichannel heads.



BK-1605 series—simple mounting and adjustment, ideal for drum computers.



BK-1501 series—compact, wafer-thin, permit individual adjustment.



BK-900, BK-1000, BK-1200 series—variety of types for single channel applications

MORE TRACKS PER INCH

with perfect channel spacing

THIS magnification check is one of many that verifies accurate channel spacing and alignment of Brush multichannel heads. In some cases, tolerances of less than .0002 in. must be observed.

This precision pays off in performance—permitting interlacing of heads for greater density of information. Thus you can design computing or data handling equipment with increased storage capacity. In addition, dimensional accuracy permits interchangeability and standardization.

For complete information on standard magnetic heads, or special designs to your requirements, write Brush Electronics Company, Dept. A-30, 3405 Perkins Avenue, Cleveland 14, Ohio.

BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

BRUSH
ELECTRONICS

Division of
Clevite Corporation

For more information circle **17** on inquiry card.

The Instrument Salesman

Panhandle Pete

Blue Monday, January 1955. Got up early, called the Boss at his home, then started down to Weirton and Steubenville to call on Messrs. Francy, Baker and Bedortha at Weirton Steel Company and Messrs. Cauger and Cousley at Wheeling Steel Corporation. It was cold and cloudy weather which soon started to rain and freeze on everything. Decided to keep going but at Windy Hill the road was blocked by a truck tie-up so detoured down through Burgettstown. Slid off the road and had to be hauled out. Cost one hour's time and twenty dollars. Finally made it to Weirton by noon and had lunch with Messrs. Francy, Baker and Bedortha. My Gawd but they can eat!

Arrived back in the mill and just started a sales pitch when the office phone rang and Baker took off on a breakdown. Several minutes later the phone rang again and Bedortha says he has to go some place. Just as I re-started the pitch again, the phone rang for the third time and I'll be darned if Francy didn't say he had to go. By golly, if I didn't know better I would think this bunch had planned all this. But they wouldn't do a thing like that! Or would they? Francy said to hang around awhile as he would be back soon.

After waiting an hour and a half, decided I'd better go over to Steubenville. Couldn't get my car started —battery dead—and as the roads were very bad by this time I thought "To hell with it. I'll leave the car here and go see Ed and Dave the next time. I'll go home by train and be safe." So I left a note for Baker, called a taxi to rush over to the railroad station and catch No. 204 to Pittsburgh at 4:45 p.m. Taxi driver got arrested in Weirton for reckless driving. Paid his fine. Got caught in the traffic jam on Fort Steuben Bridge. Just made it to the station at 4:44. No train—Doesn't run on Mondays—next train at 7:22 p.m.

COMPLETELY AUTOMATIC FACTORY

Having time to kill I decided to call on the Wheeling Steel boys after all. At least I can find out how things are. Things are slow! Dave bought a quart of ink. Mentioned having supper with them. Both Dave and Ed showed up at the Fort Steuben Hotel and after having steak dinners I started in on the old sales pitch but, because of the unfavorable atmosphere, the boys suggested going out. So we ended up at Bill and Fae's Cafe on North Sixth Avenue. Never did get anything else sold, missed the 7:22 train, almost made the *American* and dimly remember being helped onto the *Cincinnati Limited* at 10:47. . . . Conductor woke me up wanting a ticket. Told him patiently that I had already given him a ticket. Found out that the train was just past Pittsburgh and on the way to New York. Gave the conductor five bucks to slow down the train going through East Liberty so I could jump off. Fell down and lost seat of trousers on platform so had to take taxi home.

Up bright and early the next morning; went out to get in car to go to office. No car! Remembered leaving it in Weirton. Taxied to the office, called Baker at Weirton and found out that car had been towed in for over-time parking. Owed City of Weirton twenty bucks. Debated whether to let them keep car but Boss says to go get it.

Went back to Weirton on bus, got car out of hock, bought new battery and then tried to call on Baker, Bedortha or Francy. Nobody around—Busy? Ran out of gas on the way home and spent an hour getting some; arrived at the office in time to help close the doors. Results! Sold one quart of ink (red) and spent close to ninety bucks.

Panhandle Pete

While "Panhandle Pete" is recovering from a slight coronary (brought on, no doubt, by activities such as the above), we are using some of his columns that appeared in "Pittsburgh Headlines."—Ed.

BRISTOL'S

INSTRUMENTATION

BRISTOL ELECTRONIC DYNAMASTERS will measure and automatically control any variable — from temperature to viscosity

ANY VARIABLE that can be translated into an electrical quantity — temperature, pressure, pH, voltage, speed, smoke density, resistance, and hundreds of others — can be measured, recorded, and automatically controlled by Bristol's Electronic Dynamaster® Potentiometer and Bridge instruments.

Whatever your measurement or automatic control problem may be, whether it be in the plant, laboratory, or pilot plant, there is a Bristol Electronic Dynamaster for it.

ADVANTAGES of the Bristol Electronic Dynamaster:

1. Continuous standardization with no dry cells, eliminates need for dry cells and standardizing mechanism — Results: no interruption to control, no batteries to replace.
2. High accuracy . . . fast operation . . . continuous electronic measurement.
3. Simple in design . . . few moving parts.
4. Easy to use and service . . . little or no maintenance required.
5. Flexible in application.
6. Rugged in construction . . . especially built for industrial plants, pilot plants, and for research and laboratory use . . . unaffected by vibration.
7. Plant operating men quickly become familiar with this instrument and like to use it.

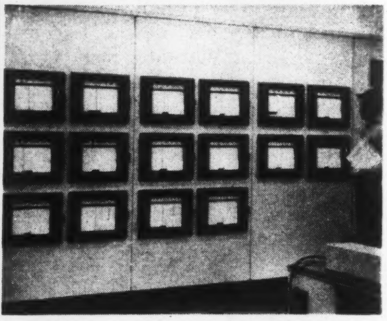
MODEL FOR EVERY REQUIREMENT. Dynamaster Potentiometers and Bridge Instruments are available as single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments and as round-chart instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip-and round-chart instruments are made in a very wide variety of controllers that meet every control requirement, including the following in a great many forms:

Electric Control — on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

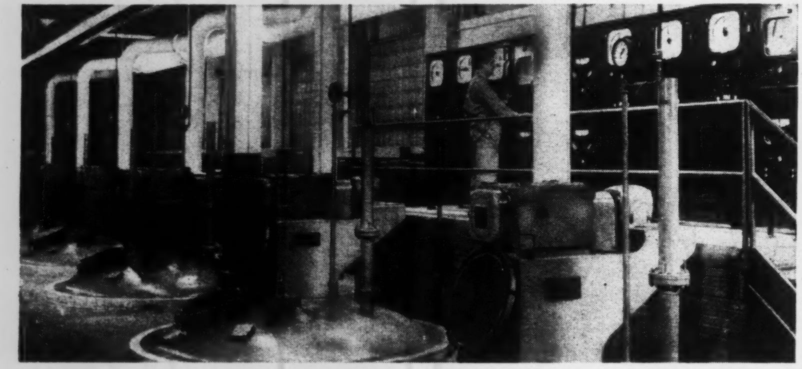
Pneumatic Control — on-off, proportional, proportional with reset, and proportional with reset and derivative.

Sun Oil Plant uses Dynamaster Recorders



Dynamaster Multiple-Point Temperature Recorders are used in the Control Room of the huge new 15-million-dollar Petrochemical Plant of Sun Oil Company at Marcus Hook, Pa. The plant produces chemical grade benzene, toluene, and xylenes.

Some of the instruments shown measure the temperatures of feed stock into and out of heaters, at dozens of points. Others record temperatures in cylindrical reactors, where the petroleum molecules are rearranged (reformed) in the presence of the platinum catalyst.

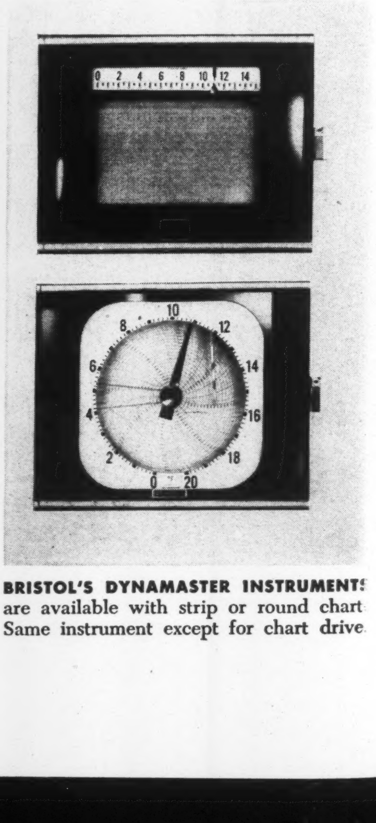


LIQUID LATEX TEMPERATURE is controlled precisely to remove ammonia from natural latex prior to foaming in this plant.

Automatic plant uses Bristol's Dynamaster Instruments

Automation is a reality here at the Buffalo Foam Rubber Products plant of the Dunlop Tire and Rubber Corporation. This automatic plant, designed and built by Mechanical Handling Systems, Inc., Detroit, uses Bristol Dynamaster Electronic Instruments and Automatic Controllers as part of a process employing today's most advanced automatic production techniques. The result — greater efficiency and productivity, lower costs, improved product.

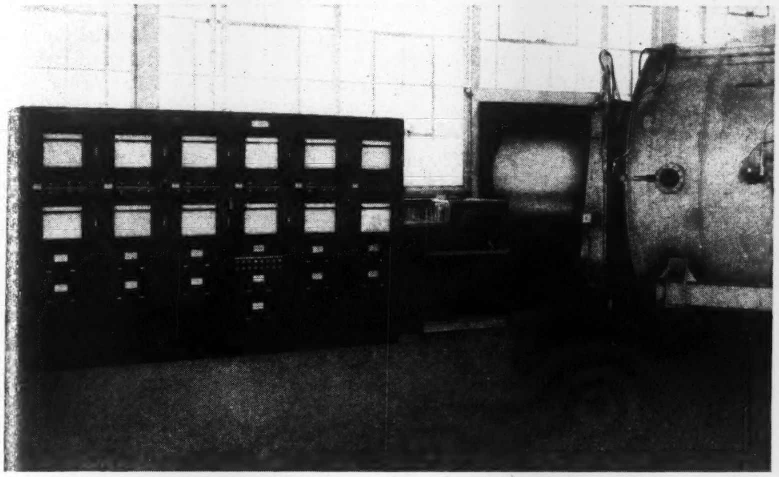
For more information circle **18** on inquiry card.



BRISTOL'S DYNAMASTER INSTRUMENTS are available with strip or round chart Same instrument except for chart drive

NEWS

. . . news and information about automatic controlling, recording and telemetering instruments from Bristol . . . leaders in human-engineered instrumentation



BRISTOL'S DYNAMASTER INSTRUMENTS record test data from wind tunnel (right) and feed information to card punching machines at United Aircraft's Research Dept.

Bristol's Dynamaster Recorders feed analogue-to-digital converters

At United Aircraft Research Dept., Bristol's Dynamaster Recorders not only supply high-speed chart records of wind tunnel tests but feed analogue-to-digital converters that punch test data on cards, at 100 cards per minute, for analysis by electronic computers.

Dynamasters in this installation record the output of strain gauge pick-ups placed on test models in the wind tunnel. The models are subject to air at supersonic-velocities.

High-speed Dynamaster Recorders (1-second full-scale pen travel) inform test operators of test conditions *between* card punchings. Since the test only lasts from 10 to 20 seconds, it is vital that every bit of information be gathered for analysis.

Dynamasters aid gas dispatching in Midwest

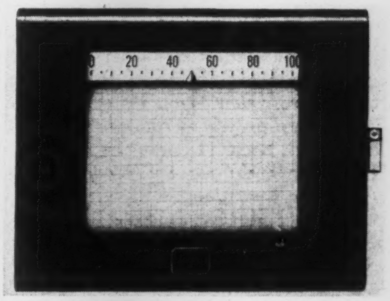
Bristol Dynamaster Metameter Telemeters, at a large midwestern gas utility, help gas dispatchers route gas throughout their distribution system.

These strip-chart Dynamaster Metameter Telemeters record gas pressure at strategic points in the system. This information used to be called in periodically by field men—a slower and less accurate process.

Using the continuous, accurate, up-to-the-minute information supplied by the wide-strip telemeter receivers, the gas dispatcher effects much better pressure regulation in the gas supply than with the old system—particularly during periods of unexpected demand.

New high-speed electronic Dynamaster Recorder

0.4-second for full scale pen travel



NEW 0.4-SECOND Dynamaster recorder

Freedom from overshoot on long or short traverses is a key feature of Bristol's new high-speed Dynamaster Recorder.

This high-speed instrument sets new standards for chart recorders in the fields of rocket and jet-engine testing, wind tunnel measurements, automatic-machine-tool control, scientific laboratory testing and numerous industrial applications.

SPECIFICATIONS:

Speed: 0.4 second to within 0.25% of balance for full-scale step-response without overshoot.

Sensitivity: Dead band less than 0.1% of full scale.

Ranges: Minimum range of 1 millivolt d-c.

Chart: 12¼ in., 11 in. calibrated.

Chart Speeds: Up to 4 in. per second.

No matter what your measurement problem is, a Bristol Dynamaster Potentiometer or Bridge instrument will solve it for you.

Write for all the facts

To get the whole story on these rugged, precision instruments, write today for your free copy of the 36-page bulletin P1245. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

5.24

. WHAT'S NEWS AT BRISTOL... WHAT'S NEWS AT BRISTOL ... WHAT'S

For more information circle **18** on inquiry card.

INSTRUMENTS and AUTOMATION News

Principles & Applications ....414 to 428
Stock Report 428
New Plants & Mergers ....441 to 442
People in the News ....445 to 448

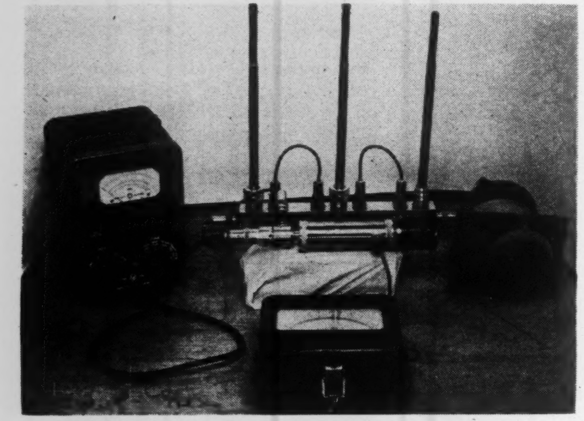
Ultrasonic Manufacturers' Association

HARTFORD, CONN.—Formation of the Ultrasonic Manufacturers' Association has been announced by its newly elected officers. Comprised of the leading manufacturers in the field of ultrasonic equipment, the U.M.A. will disseminate information, promote the industry growth, and aid its members to secure realistic rulings from government agencies such as the FCC. W. C. Potthoff (Aeroprojects, Inc.) is President of the U.M.A.; Stanley B. Rich, (General Ultrasonics Co., 1240 Main St., Hartford 3, Conn.) is Vice-President; Norman Branson (Branson Instruments, Inc., 430 Fairfield Ave., Stratford, Conn.) is Secretary.

Texas A&M Conference

The Eleventh Annual Conference on Instrumentation for the Process Industries, sponsored by the Chemical Engineering Department of Texas Agricultural and Mechanical College, January 25-27, 1956 attracted nearly 400 people, mostly from Texas, but some from California, Chicago, Cleveland, Pittsburgh and the Eastern Seaboard. The well attended lectures and the Exhibit made it an outstanding success—bigger and better than in previous years.

R-F Voltmeters

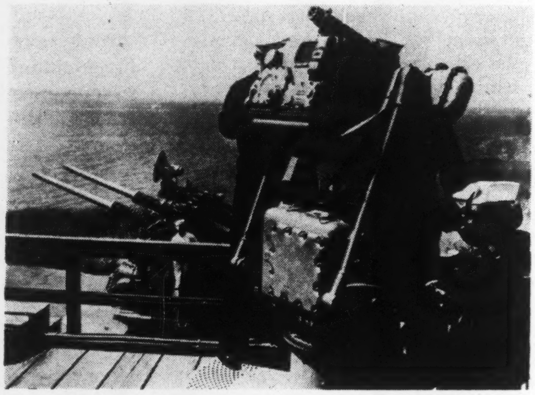


WASHINGTON, D. C.—A very stable type of radio-frequency voltmeter, known as an attenuator-thermoelement (or AT voltmeter) has been designed by M. C Selby and L. F. Behrent of the National Bureau of Standards and Boulder Laboratories. Unlike instruments now available, AT voltmeters maintain a stability well within the accuracy of the original calibration—about one percent over most voltage and frequency ranges—for a year or longer.

AT voltmeters can be used to measure RF voltages from 0.1 to several hundred volts at frequencies up to about 1000 Mc. Present-day voltmeters using thermionic or crystal diodes are generally not reliable as laboratory reference standards for a reasonable length of time.

The most stable elements suitable for calibrated-type RF voltmeters are thermoelements, waveguide-below-cutoff or capacitive-type attenuators, capacitive voltage dividers, and some well-constructed resistive attenuator pads. Several combinations have been developed to cover various ranges.

Mk 63 Gunfire Control



WASHINGTON, D. C.—Cleared by Security Review, Dept. of Defense, first details of U. S. Navy's Mark 63 gunfire control system capable of tracking speedy jet aircraft with 3-inch and 5-inch naval guns in any weather, have been disclosed.

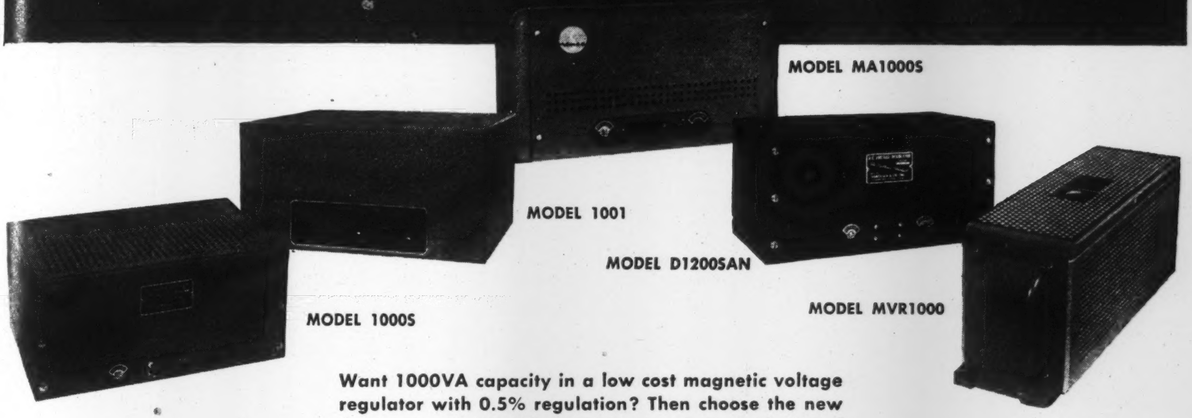
Jet capability of the director gear (manufactured by Sperry Gyroscope Company, Division of Sperry Rand Corporation, Great Neck, New York) results from combining newer gunfire controls and radars with the gyro-optical tracking principles of World War II gunsights. Radar, in conjunction with visual gyro tracking, is used for low-visibility conditions; also supplies instantaneous range and speed information. For these data, automatic computers predict needed lead angle and elevations, and mechanical "muscles" swing the guns in response to the signals received.

Continued on page 418

SORENSEN

ENGINEERS *STANDARD* MODELS TO MEET *SPECIAL* REQUIREMENTS

to illustrate this flexibility, engineers can now choose from five 1000VA regulators!



MODEL 1000S — Automatic wide-range electronic regulation with the original Sorensen frequency insensitive circuit incorporating the safety diode. Regulation ±0.1%.

MODEL MA1000S — For unattended installations requiring extremely dependable automatic line regulation. This tubeless unit offers stable long-life performance with minimum maintenance. Regulation ±0.5% over wide frequency range.

Want 1000VA capacity in a low cost magnetic voltage regulator with 0.5% regulation? Then choose the new Sorensen MVR1000; compact, economical. Need 1000VA, but with *0.01%* regulation? Then choose Model 1001. For *any* requirement, *any* application, there's a Sorensen 1000VA unit engineered with you in mind.

And the same thing is true for practically *any* specified requirement in the field of regulated power — whatever you need, Sorensen makes it now or will make it to do exactly the job you want done, within the limits of your particular application. Sorensen offers you the widest possible range of characteristics. For research or industry, call on Sorensen — ***the world's authority on regulated power.***

SEND FOR 1956 CONDENSED CATALOG

New and more complete — gives condensed specifications on a wide range of units for a variety of applications. Be sure you have all available information when you specify — send for your copy today!

MODEL 1001 — Developed from unique, dependable Sorensen regulating circuit, refined for ultra-precise ±0.01% regulation.

MODEL D1200SAN — ±0.25% regulation for 400 cycle industrial and aircraft requirements up to 1200VA.

MODEL MVR1000 — New low cost compact magnetic voltage regulator for less exacting applications. Fully automatic ±0.5% regulation with fast response time.

Sorensen

SORENSEN & COMPANY, 375 FAIRFIELD AVENUE, STAMFORD, CONN.

For more information circle 19 on inquiry card.

THE Heiland® 119 AMPLIFIER SYSTEM FOR OSCILLOGRAPHIC RECORDING

COMPARE THESE FEATURES WITH SIMILAR SYSTEMS:

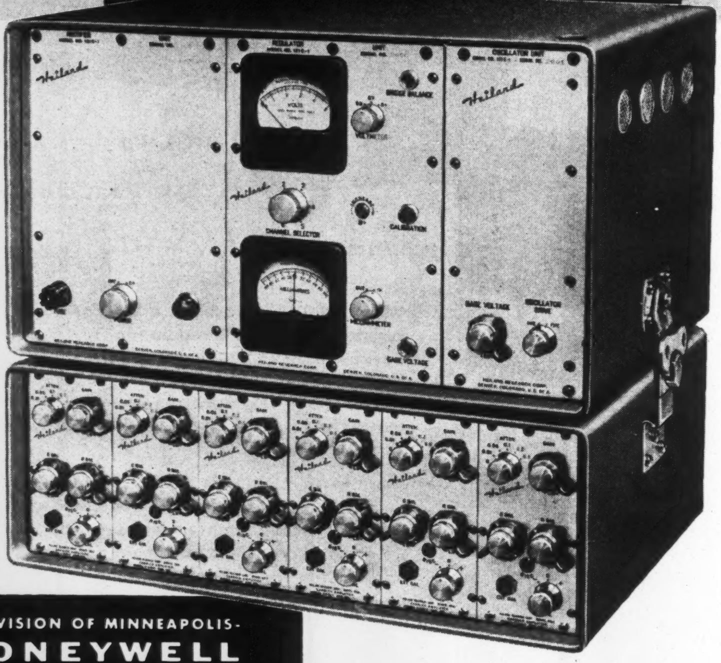
TWICE THE SENSITIVITY—½ millivolt for full current output

TWICE THE FREQUENCY RESPONSE—0 to 1000 c.p.s.

TEN TIMES THE CURRENT OUTPUT—50 ma into 20-ohm load

with-

EXCELLENT STABILITY—less than 2% variation with line voltage fluctuation and wide range of ambient temperatures



Carrier Amplifier Units for:

Resistive transducers

Linear differential transformer pickups

Variable reluctance gages

Linear-Integrating Amplifiers for:

Self-generating transducers.

Heiland® A DIVISION OF MINNEAPOLIS-HONEYWELL
5200 E. Evans, Denver 22, Colo.

FOR ADDITIONAL DETAILS WRITE FOR BULLETIN 101-A

All these features—plus many more—have moved Heiland 119 Amplifier Systems into leadership in the field!

All operating controls are on the front panel; all cabling is on the back panel for handy relay rack or test bench mounting without modification.

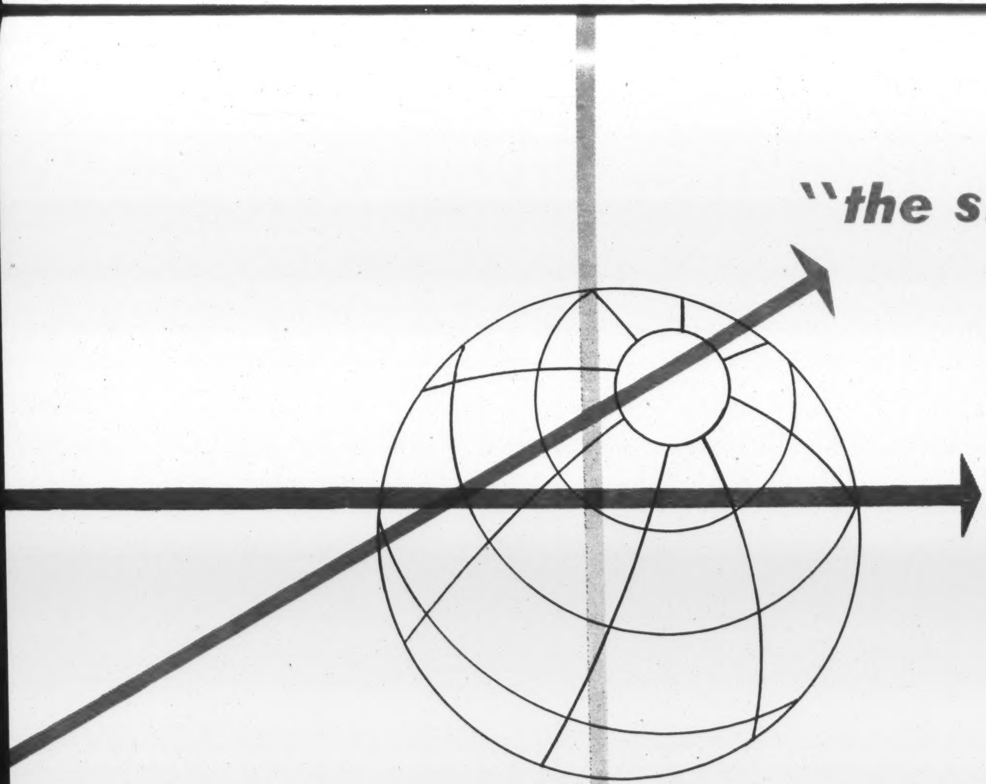
The 119 System is flexible to meet present or future needs, since all 6 individual amplifier units within the system are easily removable. You can build your system from the ground up, adding new individual units as your need expands.

In addition, linear-integrate and carrier units are interchangeable within the system case.

FOR PERFORMANCE AND CONVENIENCE—CHOOSE THE HEILAND 119 AMPLIFIER SYSTEM.

For more information circle **20** on inquiry card.

"*the show of the future*"



THIRD
INTERNATIONAL
automation
EXPOSITION

NOVEMBER 26-30
New York Trade Show Building

If you have a stake in Automation you'll want to be represented at the most dramatic industrial event of 1956.

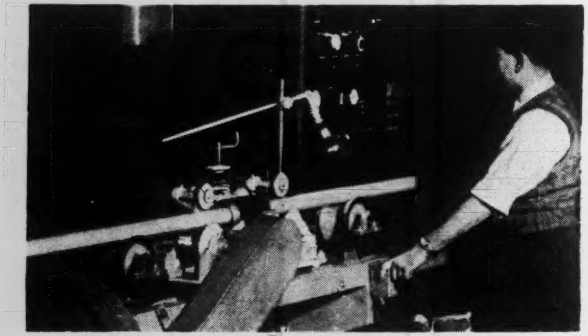
Attendance records of the past two shows confirm that this is the one exposition that attracts top-level personnel—those who purchase the systems, controls, instruments, machines and devices of automation. Advance inquiries indicate New York will attract the largest attendance yet.

Also: the Third Show will present a new concept of exhibiting—an all-inclusive price for exhibiting . . . eliminating "nuisance" charges for furniture, lighting, storing, and other services.
For brochure contact:

RICHARD RIMBACH ASSOCIATES, MANAGEMENT
845 Ridge Ave., Pittsburgh 12, Pa., FAirfax 1-9831
. . . or circle **21** on inquiry card.

Non-Destructive Tubing Test

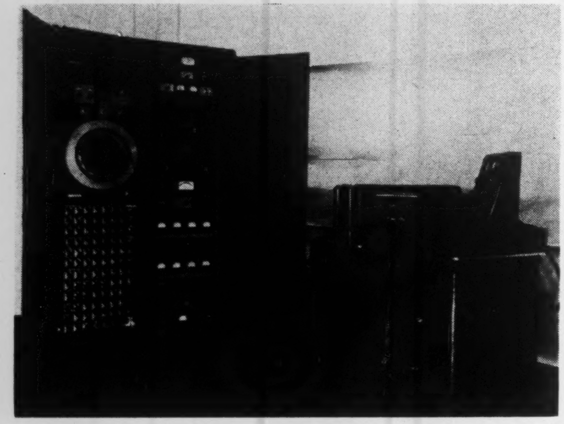
UNION, N. J.—Austenitic stainless-steel tubing at the Carpenter Steel Company's Alloy Tube Division, Union, N. J., is now subjected to closer and more critical quality control by non-destructive test equipment developed in conjunction with Magnetic Analysis Corp., Long Island City, N. Y.



The unit inspects the inside and outside diameter surfaces of tubing along the full length and around the entire periphery. It also tests the complete wall thickness or sub-surface of material with walls up to 0.070″. Inspection by this improved method surpasses test standards specified by the American Society of Testing Materials.

Automatic Machine Tool

DETROIT, MICH.—Machined-parts data on punched cards, processed by a digital computer to punch holes in a tape, which in turn is fed into an electronic control panel, have led to the development of the new "Cam" machine, conceived at the Research Laboratories Div., Bendix Aviation Corp., Detroit. The machine is a cross between a lathe and a mill and may "revolutionize the whole set pattern of product design and metal cutting."



The new concept may be described as referring the finished part's relative position to the cutting tool (a ball-end milling cutter), which rotates rapidly and moves against the part while the part itself rotates slowly. The combined motion describes a helix, which corresponds to values charted on the drawing representing the final dimensions of the piece arranged in a helical pattern. Another chart on the drawing lists the finished dimensions in the lateral direction. Transformation of electronic signals controlled by the tape into hydraulic impulses which position the tool results in 0.0002-in accuracy with feedback action completing the fully automatic operation.

Wilmington Section Symposium

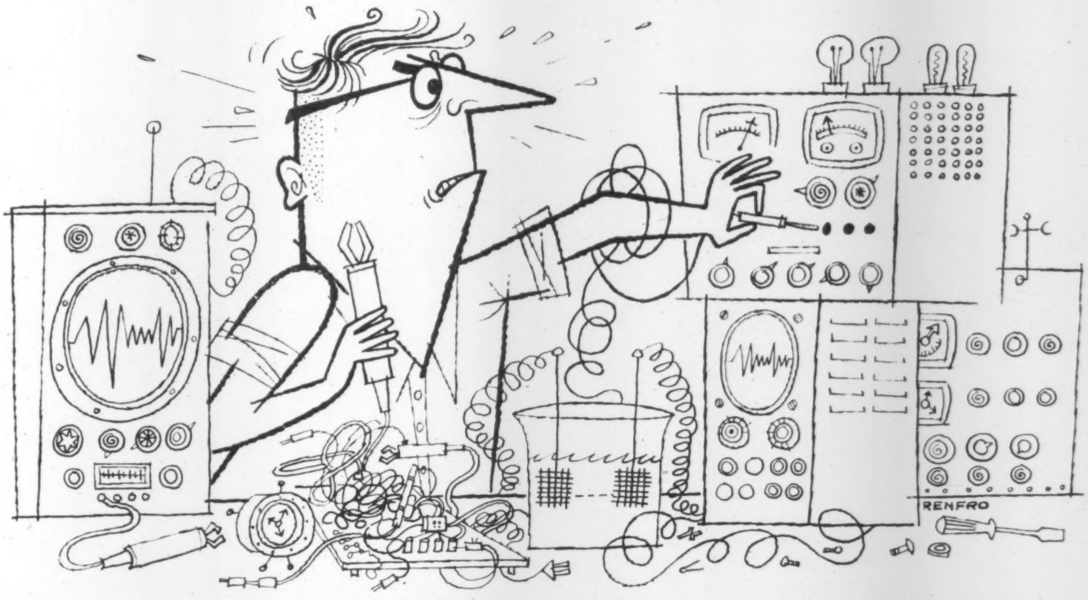
WILMINGTON, DEL.—J. Johnston, Jr., of the Wilmington Section, ISA, announces that the Wilmington Section plans a symposium on Electronic Controls in Industry, April 25, 1956, 1:30 PM, Hotel du Pont, Wilmington. Four papers on electronic control systems will be presented, and Gordon Volkenant (former associate director of research for Minneapolis-Honeywell) will give his always provocative talk and demonstration on "Mr. Electron." He is shown here with some of his paraphernalia designed to amuse and amaze the unwary.

Nuclei Under the Microscope

STANFORD, CALIF.—Stanford University scientists are working on a "nuclear microscope"—a 220-foot electron linear accelerator coupled to a 55-ton, 16-foot-high magnetic spectrometer said to be able to measure nucleons with an accuracy of 4 x 10^{-15} inch.

The picture shows Professor Robert Hofstadter (left) of Stanford's High Energy Physics Lab. with his co-workers Lance Rogers (center) and F. W. Bunker, preparing 0.003″-thick gold foil through which (much like

why fiddle and fuss?



New *-hp-* 711A Power Supply makes it *easy* to power experimental and bench setups

60 VOLTS FULL SCALE
D.C. VOLTS ADJ.
10 MA FULL SCALE
FINE
COARSE
ON
AC VOLTAGE
DC VOLTAGE

0-500 volts dc, 6.3 v ac
High regulation
Current, voltage meters
Overload protection
All-purpose utility

The new *-hp-* 711A was developed to do just one thing—simplify your job of powering all kinds of electronic circuitry in laboratory, field and factory.

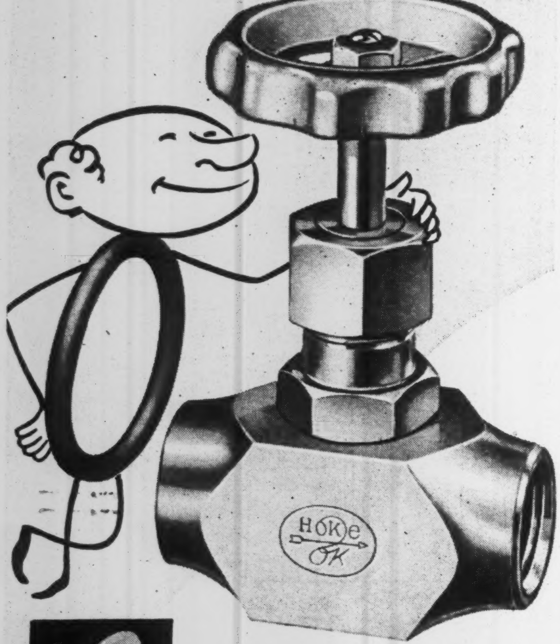
This compact (18 lbs.) instrument is ideal for driving low level amplifiers, constant frequency oscillators and similar jobs where highly stable voltage is essential. Voltage range is very broad—0 to 500 volts. No-load to full-load regulation is better than ± 0.25% or 0.5 volts. Ripple is less than 1 millivolt. Maximum current is 100 milliamperes.

For added convenience, there are separate current and voltage meters with new push-button range switching for accurate measurement of small voltages and currents. Other features include overload protection and grounding on either positive or negative dc terminals. The price is $225.

Electronic instruments for complete coverage, quality, convenience

HEWLETT-PACKARD COMPANY
3332C PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.,
DAvenport 5-4451 • Cable "HEWPACK"
Field Representatives in all principal areas

For more information circle **22** on inquiry card.



O-RINGS

are a valve's best friend

Let's face it . . . dripping, leaky valves are just not socially acceptable . . . so, we designed the new Hoke bar stock needle valve with an O-ring stem seal—to give it the right start in life. Result—a seal that will pass a helium leak test and no leaky, messy packing adjustments—ever. No friction either (even at high pressure)—you can operate the valve with a fingertip touch. There's a new, self-aligning spindle which shuts off tight time after time without galling or binding.

As you can see, the Hoke bar stock valve will contribute ease of operation, low maintenance cost and neat appearance to your equipment—hydraulic, pneumatic, instrument panel or test stand. It's available from stock in a wide range of sizes (1/8" to 1/2" pipe) and materials (carbon, chrome or stainless steel and brass) . . . panel mounting, too if you need it. We'd like to send you our Bulletin.

P.S. We've just published a new wall chart on Hoke valves with valuable information on valve sizing and corrosion resistance. May we send you one?

HOKE

HOKE INCORPORATED
Fluid Control Specialists
231 S. DEAN STREET, ENGLEWOOD, N. J.

For more information circle **23** on inquiry card.

the principle of the electron microscope) electrons of 550 x 10^6 volts will be shot. Stepping up the voltage by a factor of more than 500 has increased the particle size 100,000 times. No photographic picture is taken, but a 200-kilowatt magnetic spectrometer gathers the electrons, counts them, and measures their energy losses and angles of deflection. Calculations will do the rest to furnish graphical details which cannot be photographed.

Preliminary findings indicate a uniform skin thickness for nuclei of gold, cobalt, calcium, carbon and othe elements. The skin is fuzzy, like a tennis ball.

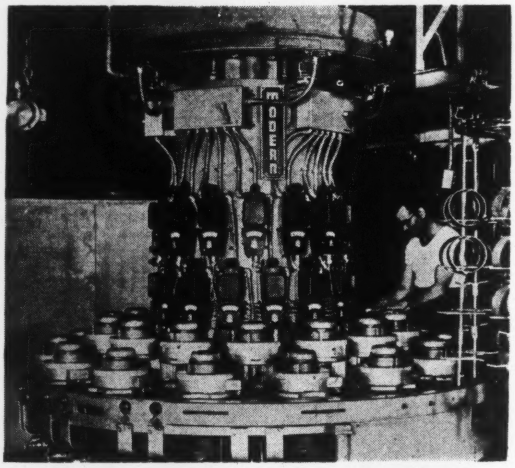
Eastern Simulation Council forms Study Groups

The ESC Steering Committee has decided to supplemen the bimonthly meetings with study groups whose functio it will be to investigate specific phases of simulation.

To initiate the program, the steering committee ha set up five study groups: (1) *System Design Using Computers*—chairman: H. Wexler, Sylvania Electric Products, Missile Systems Lab; (2) *Analog Recording*—Jules Lehman, Radio Corp. of America; (3) *Dead Time Simulation*—B. Loveman, Reeves Instrument Corp.; (4) *Use of Noise in Simulation*—R. Favreau, Electronic Associates, Inc.; (5) *Single Amplifier Transfer Functions*—H. Mori, Dynamic Analysis & Control Lab., MIT.

Brake-Band Instrumentation

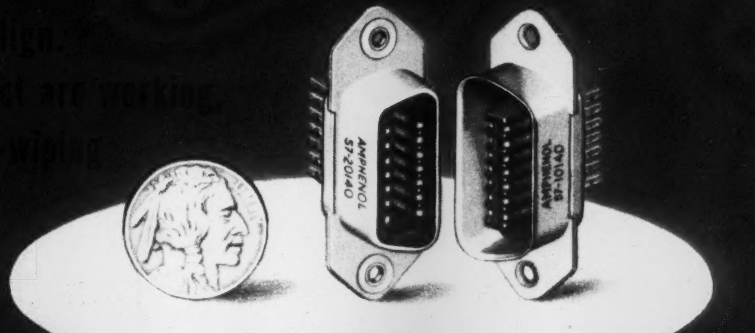
DETROIT, MICHIGAN—High output of bonded automatic transmission brake bands is realized at the Muncie, Indiana, plant of Warner Gear Division, Borg-Warner, Corporation, using a single 30-station rotating machine designed and built by Modern Industrial Engineering Company, Detroit, Michigan.



An air regulator valve at each station controls uniformity of the pressure, and each station also has it individual adjustable temperature control. Adhesive-coated molded brake band linings are placed into the metal bands for bonding and put on the segmented mandrel

Circle **24** on inquiry card.→

Miniaturization
plus increased reliability,
easy, smooth insertion and extraction,
no pins to bend or misalign.
Both sides of the contact are working,
flexing members . . . self-wiping
and self-cleaning.

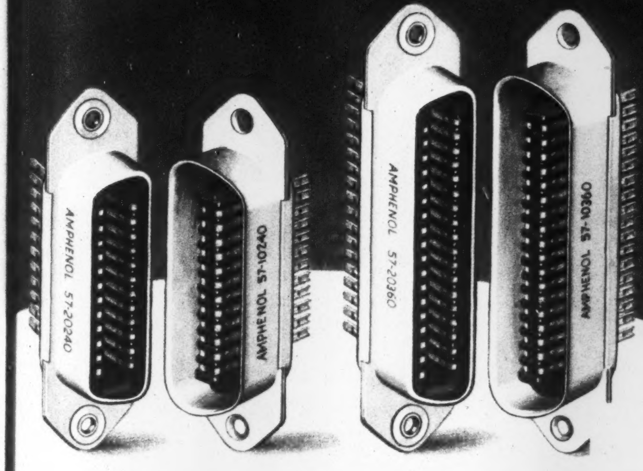


14 CONTACTS

new! Micro-ribbon connectors

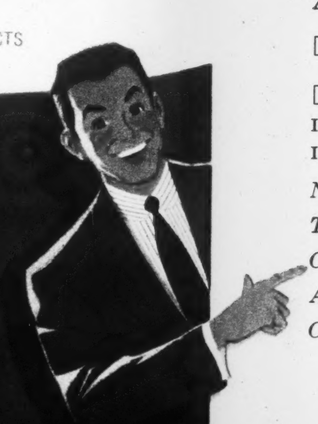
AMPHENOL
Micro RIBBON

New Micro-Ribbons are the first miniature connectors to provide reduction in size with increase in reliability. Utilizing an improved 'ribbon' contact, Micro-Ribbons provide easy insertion and extraction even in blind entrance locations. Both mating contacts are self-wiping, self-cleaning, active, flexing members—provide double contact action at all times. Send card for Catalog R2!



24 AND 36 CONTACTS

Micro-Ribbons
illustrated
actual size



American Phenolic Corporation, Chicago 50, Illinois

☐ send me R-2 catalog which includes a complete listing of available MICRO-RIBBON CONNECTORS.

☐ send new Hermetic Seal brochure.

I would like ☐
I am receiving ☐ your periodical "Amphenol Engineering News"

*Name*______________________________

*Title*______________________________

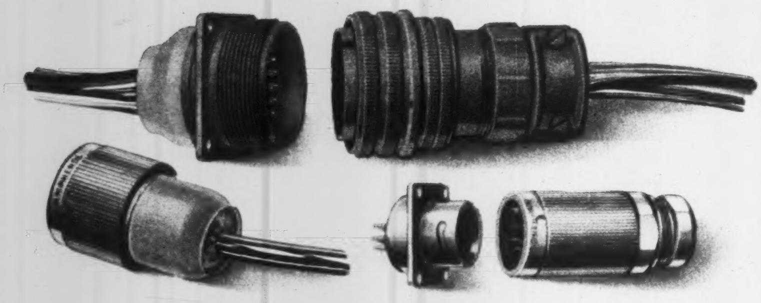
*Company*______________________________

*Address*______________________________

*City*____________________ *State*__________

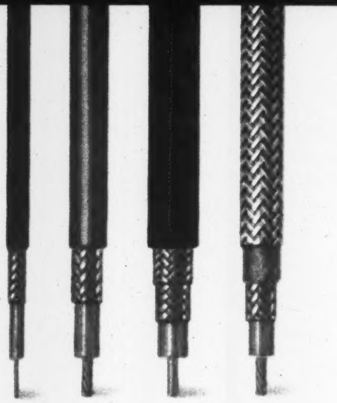
THIS CARD TEARS OUT

AN CONNECTORS



165 SERIES CONNECTORS

Amphenol AN connectors are the 'workhorses' of electronics, providing dependable service in literally thousands of applications. From the basic AN design have evolved AN connectors for potting (pioneered by **Amphenol**) and the 165 Series of Miniature AN-type connectors, also available in potting and pressurized constructions. ANs, 165 Series and all **Amphenol** electrical Connectors are listed in Catalog A4.



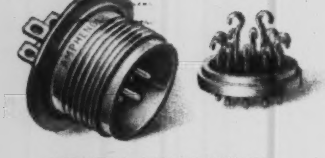
RF CABLES

Teflon and polyethylene RG-/U coaxial cables, miniature and Aljak cables—send for Catalog W1, a complete and informative catalog and manual, listing all **Amphenol** cables.

AMPHENOL
product groups

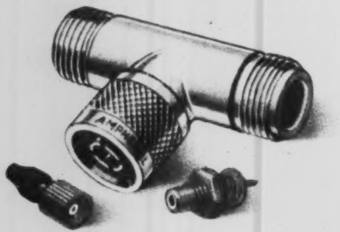
The **Amphenol** product line is comprised of thousands of electronic components—many are included in the major product groups illustrated. Not described are Cable Assemblies & Harnesses, Sockets, Plugs and the many 'specials' produced by **Amphenol**. General Catalog B4 summarizes the complete **Amphenol** product lines.

American Phenolic Corporation, Chicago 50, Illinois
Amphenol Canada Limited, Toronto 9, Ontario



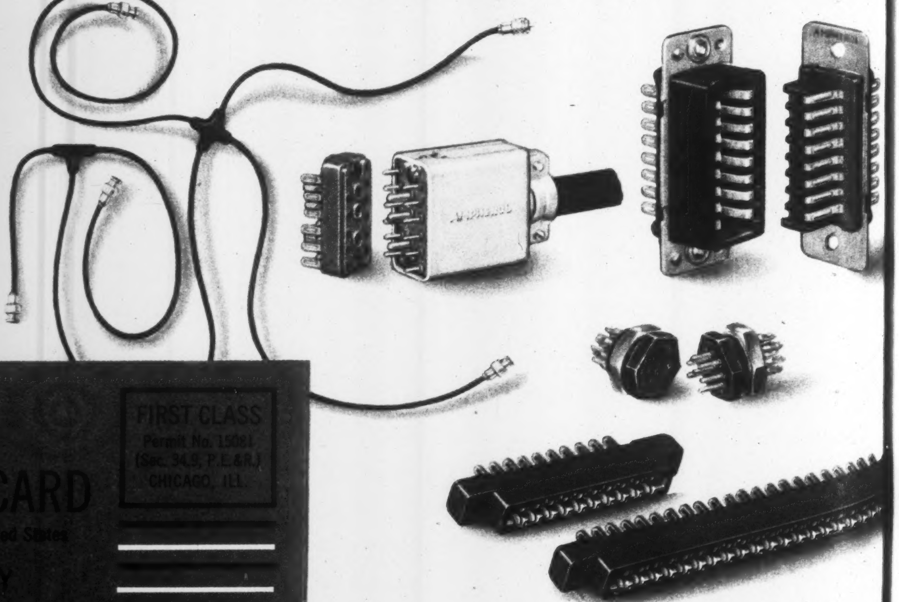
HERMETIC SEAL PRODUCTS

Brand new Headers join AN-type receptacles in the Hermetic Seal group. All have superior compression seal glass for best hermetic performance. Send for product literature!



RF CONNECTORS

All standard UG-/U types and many special application RF connectors including the new Subminax miniatures bear the **Amphenol** quality imprint. Request RF Catalog D3.



RACK & PANEL CONNECTORS

For rack & panel applications **Amphenol** offers famous Blue Ribbons, miniature and standard pin & socket types and a complete line of Princir (printed circuit) connectors. Designed and manufactured to **Amphenol** standards. Catalog R2.

FIRST CLASS
Permit No. 15081
(Sec. 34.9, P.L.&R.)
CHICAGO, ILL.

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

American Phenolic Corporation
1830 South 54th Avenue
Chicago 50, Illinois

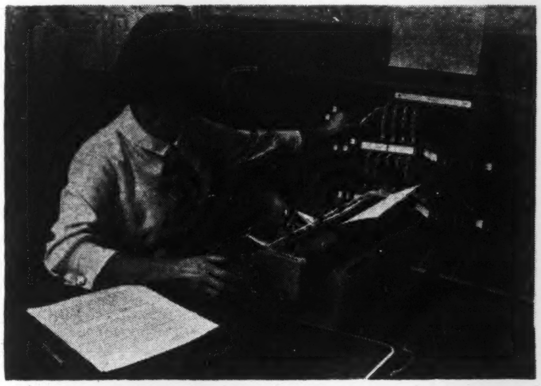
AMFORM 2725-26300

PRINTED IN U.S.A.

by the operator at the start of the cycle. Air pressure applied through a cylinder at each work station forces jaws apart, holding the lining to the metal band under heat and pressure.

For Women only . . . Cataloging Type Bars

LOS ALAMOS, NEW MEXICO.—The large number of exchangeable type bars available for IBM typewriters has given Miss Virginia Brennan, Secretary at Los Alamos Scientific Laboratory, University of California, an idea of how to locate them easily (unusual characters such as square root signs or Greek letters keep popping up in her manuscripts).



Of the 44 key positions on an IBM keyboard (which includes positions 0 and 43 as extras on either end of the first row) 17 are made exchangeable. Different curvature assigns them a definite location on the keyboard. A modified Linedex is used to hang the bars in a systematic arrangement with a fine code worked out by Miss Brennan leading to hieroglyphicals. A program shows at a glance what characters appear in the play, assigns them their proper location, and there they wait patiently for their clue to jump onto the keyboard and put on their act.

News Bits

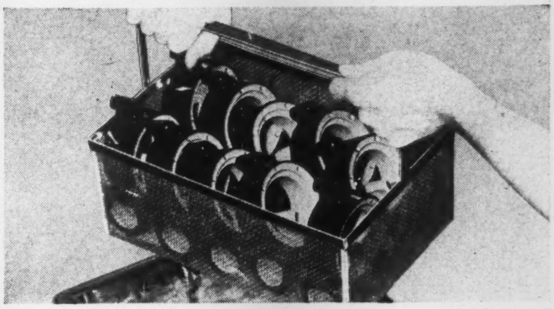
EXPERIMENTS ON SMOG CONTROL are being carried out in the Los Angeles area by investigators using a Beckman IR-2 infrared spectrophotometer which is split in half; the two sections are placed 175 feet apart to analyze the atmosphere lying between.

PG (polishing and grinding) **WHEELS** consisting of hundreds of pieces of cloth coated abrasives factory-formed into a wheel are hailed by the developer (Minnesota Mining and Mfg. Co., St. Paul) as "the most significant development in polishing methods since the end of World War II." The 3 M Company describes their action as removing stock as part of its polishing action whereby mild draw marks can be removed while generating buff type finish in the same process.

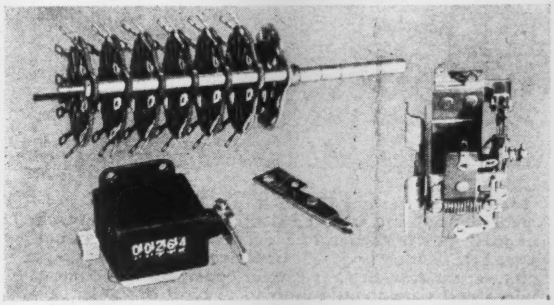
ELECTRONIC ENGINEERING CO., Los Angeles, has delivered the first of six data transmission sets to the Air Force Missile Test Center, Florida (the launching site of the earth satellite). The unit furnishes plotting data on guided missiles.

←Circle **24** inquiry card.

PIONEERING is our business



ELIMINATE YOUR CLEANING PROBLEMS WITH



Bendix ULTRASONIC CLEANING SYSTEMS FROM

Pioneer-Central

Dip housings having small holes, threads and other hard-to-reach places (top picture) into the Bendix Ultrasonic Cleaner. In *seconds*, they are cleaned more thoroughly . . . *using only a water-detergent solution* . . . than by any other cleaning method.

With a Bendix Ultrasonic Cleaner, removing contamination from complex and fragile assemblies (bottom picture) becomes *routine*, so quickly and effectively is the job done. Even radioactive contaminants baked on under high temperatures over an extended period of time pose no problem for the Bendix Ultrasonic Cleaner. For, in *two minutes*, 99.5% to 99.9% of this radioactive contamination can be removed.

Cleaning costs go 'way down with a Bendix Ultrasonic System, too. Within months, time and labor savings alone can easily pay for the cost of the System. In addition, for most applications you need only use an inexpensive, non-flammable, non-toxic water-detergent mixture.

Break away from out-moded, messy, dangerous and inefficient cleaning methods. Join the growing number of industrial concerns that do the job better and more economically with a Bendix Ultrasonic Cleaning System. Write PIONEER-CENTRAL DIVISION, BENDIX AVIATION CORPORATION, DAVENPORT, IOWA.

West Coast Office: 117 E. Providencia Avenue, Burbank, California
Export Sales and Service:
Bendix International Division, 205 E. 42nd Street, New York 17, New York
Canadian Distributor:
Williams & Wilson Ltd., 11 Front Street East, Toronto, Canada

For more information circle **25** on inquiry card.

Partners in Production

Joy Electrical Connectors
and
Automatic Controls

What happens to Automation . . . when electrical connectors fail?

No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.

Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.

Free . . .
New Bulletin —
Ask for No. B59

CD 355.2

JOY
SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

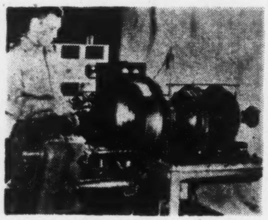
For more information circle **26** on inquiry card.

NEWS—CONTINUED

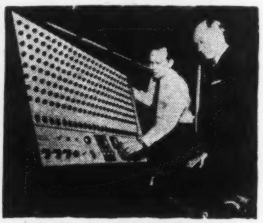
BRITISH LEAD WITH LESS—The television critic of the New York Times reports in a dispatch from London that the quality of British TV is higher than ours, whereas our 525-line system should be better than the British 405-line system. Reason seems to lie in the camera and transmitter, with the British constructed more meticulously. Shame on us!

JERKMETER for ballistocardiography has been developed by Thomas A. Perls and Charles W. Kissinger of the NBS. (A "jerk" is time derivative of acceleration.)

INTERNATIONAL RESEARCH & DEVELOPMENT CORP. has built a vibration analyzer for dynamic balancing of Seagrave Corp.'s truck engines and 10,000-rpm pump impellers. Custom charge of $3.00 was cut to 14.6 cents per unit by the new methods.



IRD Vibration Analyzer



Beckman 200-channel data reduction unit

BECKMAN DIVISION has developed a 200-channel data reduction unit to record the "give" at as many locations on an airplane. Tiny strain gages serve as primary elements. Lockheed Aircraft will use the unit.

ELECTRONIC NOSE is an appropriate new term for a device to measure air contamination under development at Purdue University. The AIEE disclosed its existence at its January General Meeting.

LEEDS & NORTHRUP CO. will supply the complete control instrumentation for a critical reactor which Combustion Engineering is building for the AEC as a submarine nuclear propulsion unit.

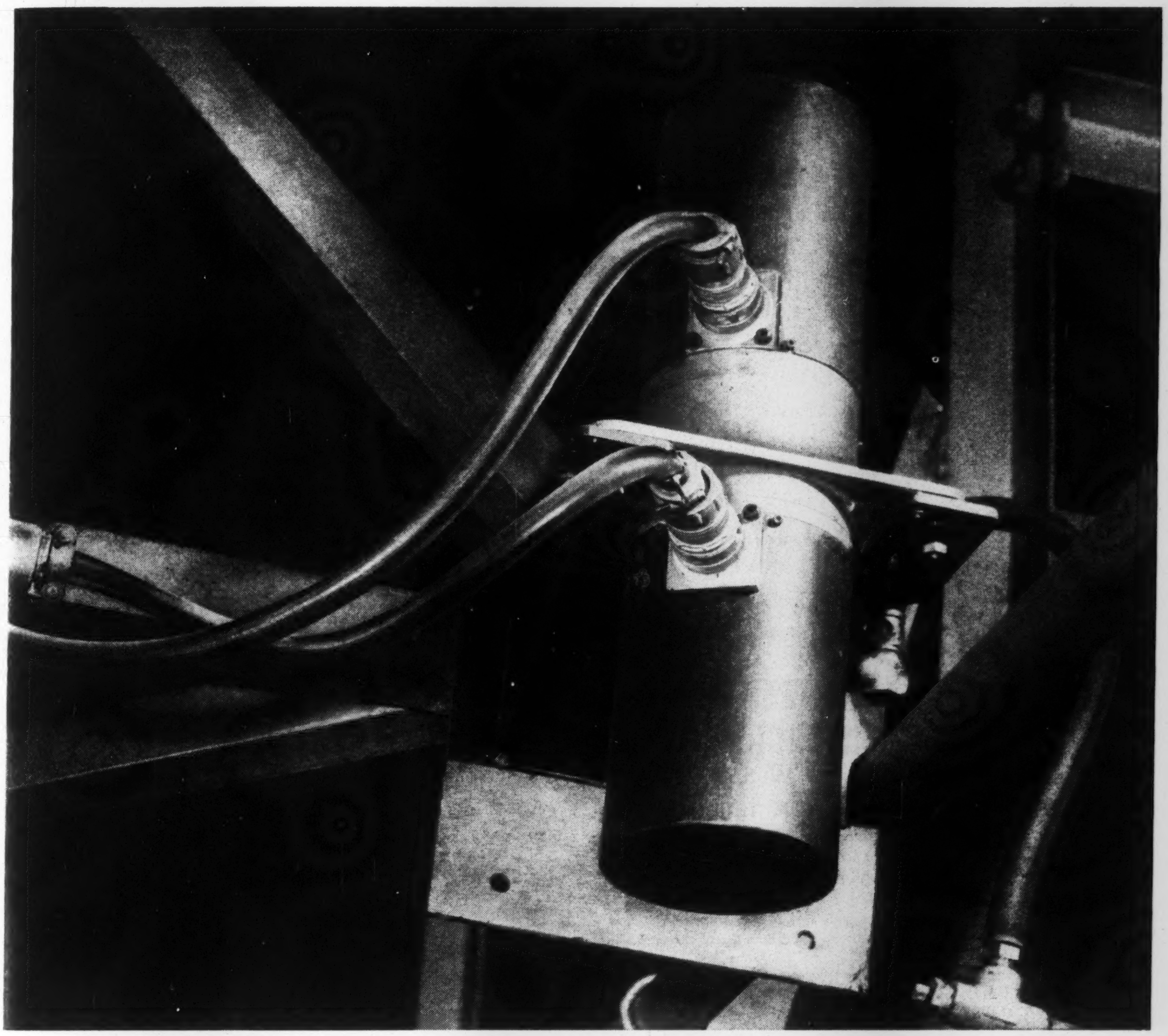
GENERAL ELECTRIC is giving the ASTM a hard time to maintain validity of its 35-year-old standard test-gap for measuring dielectric strength of oil in power transformers. The High Voltage Lab. in Pittsfield, Mass. uses hemispheric electrodes and other aggravated test conditions, as has been done in Germany and Great Britain.

CASE INSTITUTE of Technology in Cleveland, which has pioneered in instrumentation courses, will again offer a three week summer study course in June featuring frequency techniques.

THE TRANSOSONDE is a new meteorological data gathering system developed by the Naval Research Laboratory for weather forecasting. High-frequency radio direction-finder stations track balloons thousands of miles.

LIBRASCOPE, INC. played host to a group of young engineers and scientists as first stop in NOTS' (Naval Ordnance Test Station), Pasadena, program to acquaint junior professionals with local Navy contractors.

GENERAL ELECTRIC (Electronics Pk., Syracuse) has developed a 100-kw VHF TV broadcast antenna; most powerful VHF TV transmission now in operation is 50 kw.



Hagan electronic transducer on engine test cell — key sensing instrument in the simulated altitude control system.

Hagan controls a 1500 mph wind at A.E.D.C.

Hagan controls and instruments maintain high altitude flying conditions in the Engine Test Facility altitude test cells at the Arnold Engineering Development Center, Tullahoma, Tenn. Hagan systems now in successful operation include automatic pressure controls for altitude simulation; surge and motor load limit controls on blowers and exhausters; and pressure controls on exhausters. The Hagan systems allow test engineers to produce conditions within the test cells which simulate flight conditions up to 80,000 feet. These controls provide the flexibility and power for any desired testing procedure.

Hagan has been producing automatic control systems for more than 35 years, and aeronautical testing facility controls since 1939. Hagan has pioneered in the design and production of high speed, high precision devices such as electronic transducers, controllers, computers, amplifiers, electro-hydraulic operators and electro-hydraulic pilot valves capable of delivering up to 300 hp. These are available as standard components.

Hagan is prepared to design and furnish complete control systems for aeronautical testing facilities or other process control functions.

HAGAN CORPORATION

HAGAN BUILDING, PITTSBURGH 30, PA.

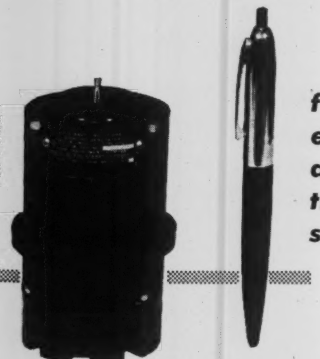
HAGAN

Systems and Components for: Aeronautical Testing Facilities, Process Control, Boiler Combustion Control, Metallurgical Furnace Control • Industrial Water Treatment • Chemicals for Water Conditioning

HAGAN SUBSIDIARIES: CALGON, INC. • HALL LABORATORIES, INC.

For more information circle **27** on inquiry card.

NOW YOU CAN BUY *Telesyn®* SYNCHROS OFF THE SHELF!



for extreme accuracy in transmitting signals . . .

SHIPMENT GUARANTEED WITHIN 5 DAYS FOR COMMERCIAL UNITS

. . . and within 20 days for Mil Spec units.

THESE UNITS ARE NOW ON THE SHELF
(subject to prior sale)

1HG
1F
1HCT
1HDG
3HG
3F
3HCT
3HDG
5HG
5F
5D
5HDG
1HG400*
1F400*
1HCT400*

*400cy units are available to commercial specs only. All others are available to *both* military and commercial specs.

In addition to above units, Ford Instrument currently has many other sizes and types of synchros in production and approaching shelf status – also specials. Call or wire R. Banka, Component Sales Division, (STillwell 4-9000, Ext. 513) for prices, or check and mail coupon below, stating quantity. Check coupon space indicated if you wish FREE booklet on Ford's complete synchro line.

Component Sales Division
FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

Please send me prices and characteristics of the units checked below.

☐ 1HG
☐ 1F
☐ 1HCT
☐ 1HDG
☐ 3HG
☐ 3F
☐ 3HCT
☐ 3HDG
☐ 5HG
☐ 5F
☐ 5D
☐ 5HDG
☐ 1HG400*
☐ 1F400*
☐ 1HCT400*

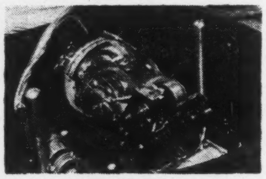
*Available to commercial specs only.

☐ Units should meet military specs.
☐ Please send me FREE booklet

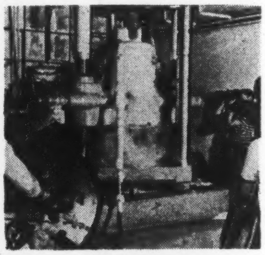
Name________________
Position________________
Company________________
Street________________
City__________ State__________

For more information circle **28** on inquiry card.

MINNEAPOLIS-HONEYWELL-built supersonic autopilots for U. S. Air Force jets are subjected to "wobble" tests to assure that allowable drift rate of gyro is less than 0.35 degree/minute.



M-H Gyro Test



B-L-H Test Machine

BALDWIN-LIMA-HAMILTON's 200-ton universal testing machine furnishes the main actor for shooting pictures of the effect of rivet spacing on joint efficiency at minus 300°F. The stage is Convair's aircraft structural test lab.

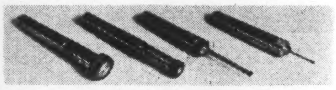
THE UNIVERSITY OF WISCONSIN Extension Division, Madison, is preparing a two-day Engineering Institute on Instrumentation for Process Control. The dates are April 19 and 20, 1956.

G-E INDUSTRIAL COMPUTER Section of the Electronics Division has been formed to market a full line of computers.

BENDIX-PACIFIC has started delivery of 57 units of MR-3 Marine Radars to the U. S. Coast Guard.

BELL TEL LABS have developed a new p-n-p type transistor for high frequency operations (500 to 600 Mc against previous max. of 200). Silicon and germanium proved equally suited.

HAMILTON WATCH CO. now produces laps made of metal-bonded diamond powder for internal grinding of hard metals, carbides and cements. Sizes range from 0.018″ to 2.250″.



Metal-bonded diamond-powder drills.

SYLVANIA ELECTRIC PRODUCTS INC. reports that net sales for 1955 ($307,371,315) exceeded $300 million sales total for the first time in company history, an increase of 9% over 1954.

FALSTROM COMPANY has installed a power press with a capacity of 260 tons, 10-inch stroke, and a 4 x 5 foot bed area for one-piece blanking, drawing, forming and embossing.

NEW CRYOGENIC LAB of NBS at Boulder, Colorado has facilities for large scale production of liquefied nitrogen and hydrogen of the para constellation which is not exothermic. Thermal conductivity data are being obtained.

AUTOMATION IN ACTION was presented in a half-hour broadcast on TV by General Controls Co., Glendale.

ELECTRON MICROSCOPES can bring out hitherto undiscernible details by a new technique developed by

TI PROGRESS REPORT ON SILICON SEMICONDUCTORS

Performance

...NOT PROMISES!

TI line of silicon transistors and diodes and stockpile of grown silicon crystals.

TWO YEARS AGO the first silicon transistors were put on the market by Texas Instruments. Enthusiastic acceptance of these high gain, high temperature units has allowed Texas Instruments to repeatedly increase production and reduce prices because of improved mass production techniques.

TODAY, after outstanding field performance under rigorous conditions, TI silicon transistors and diodes are being installed in mass-produced equipment by increasing numbers of electronics manufacturers. You can now select from TI's broad line of silicon transistors . . . the widest choice on the market . . . allowing for *complete* transistorization of many circuits.

THE 8 TYPES of TI grown junction silicon transistors range from high gain, low level units to high gain power units with up to 8.75 watts dissipation. Also, Texas Instruments produces 55 types of single crystal fused junction diodes . . . general purpose diodes in 13 voltage ratings . . . voltage reference diodes in 42 voltage breakdown ratings.

WHEN YOU PLAN transistorization or miniaturization, contact Texas Instruments first . . . your most experienced source for semiconductor devices — silicon or germanium transistors, rectifiers, and diodes.

YOUR CHOICE OF 8 SILICON TRANSISTORS

4 high temperature small signal transistors

For reliability and economy at high temperatures. Dissipation at 150°C, 50 mw; at 25°C, 150 mw. Maximum collector voltage, 30 volts.

type no.	alpha	alpha frequency cutoff (mc)	gain (db) (design center)
903	0.9 to 0.95	4 (Design Center)	30.5
904	0.95 to 0.975	5 (Design Center)	34
905	0.975 (Min.)	6 (Design Center)	36.5
904-A	0.95 (Min.)	8 (Minimum)	35

3 high temperature medium power transistors

For audio and amplifier stages. Dissipation at 150°C, 150 mw; at 25°C, 1 watt.

type no.	alpha (minimum)	collector voltage (maximum)	gain (db) (minimum)
951	0.9	50	30
952	0.9	80	30
953	0.9	120	30

high temperature power transistor

For output power stages, as in servo amplifier outputs. Dissipation at 100°C, 3.5 watts; at 25°C, 8.75 watts.

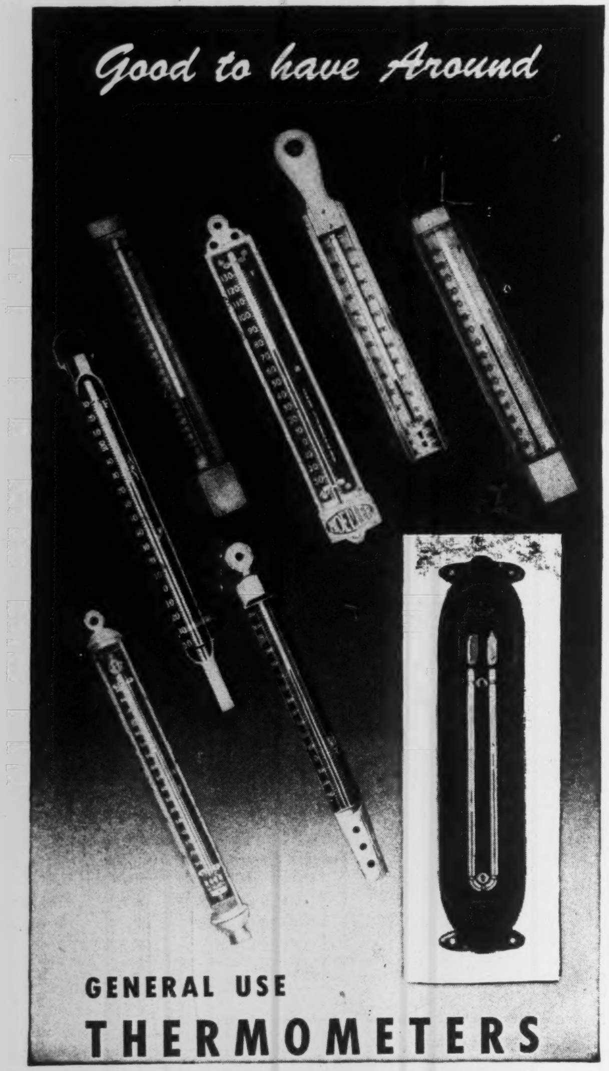
type no.	operation	output (minimum)	gain (db) (minimum)
970	Class A (100°C)	1 watt	28
970	Class B (100°C)	2.5 watts	18

LOOK TO TI FOR: SILICON SMALL SIGNAL AND POWER TRANSISTORS • SILICON JUNCTION DIODES • GERMANIUM RADIO AND GENERAL PURPOSE TRANSISTORS • SWITCHING TRANSISTORS

pioneer producer of silicon transistors

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

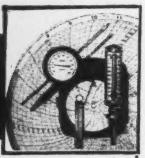
For more information circle **29** on inquiry card.



Dependability that began 88 years ago continues to serve industry with accurate and reliable thermometers.

Then as now, Moeller Thermometers unalterably live up to the high standard of performance required by modern industry.

MOELLER
INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities



Gentlemen: Without obligation, kindly send me the Moeller General Use Thermometer Bulletin.

NAME ....

FIRM ....

ADDRESS ....

CITY .... ZONE .... STATE ....

For more information circle 30 on inquiry card.

Ladd Research Industries, Inc. using X-ray-sensitive recording material.

COMPUTER-CONTROLLED TRAFFIC LIGHTS make Evansville, Indiana, the first city where statistics on the variable traffic pattern are fed back to control the duration of light signals to alleviate traffic congestion. Two GE divisions have furnished the equipment.

OPTICAL COATING LABORATORY has made its large high-pressure coating machine (capable of coating mirror's up to 60″ dia) available to the commercial trade since its primary assignment to serve military needs is nearing completion.

BALDWIN-LIMA-HAMILTON'S SR-4 load cells are reported in many new applications, as far diverse as batching of ingredients in the production of liquid sugar, and centralized distribution of airship car cable loads.

Stock Report

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York

New York Stock Exchange:

	Price Range for 1955-56 Thru January 31		As of January 31
Security	High	Low	Last
Aeroquip Corp.	17 1/2	8 1/2	13 1/2
American Chain & Cable	46 3/8	35 1/2	39 1/4
American Mach. & F.	35 7/8	23 1/4	24 3/4
American Mach. & M.	41 3/8	27 1/2	35 1/2
American Optical	53 1/4	37 1/8	37 5/8
Beckman Inst.	30 3/4	19 3/8	27 1/2
Bell & Howell	42 1/4	29	29 1/2 - 29 (1
Bendix Aviation	59 1/2	45	52 1/2
Bulova Watch	25 3/8	20 3/4	21 1/8
Burroughs	34 1/4	22 7/8	30 1/4
Clevite	25 3/8	20 1/2	21 3/4
Dobeckmun	38 7/8	30 1/4	32 1/8
Gamewell	39	27	27 1/4
General Inst.	13	7 5/8	8 7/8
General Prec.	71 1/2	36 1/2	46 3/8
General Time	39 3/4	30	30
Hamilton Watch	25 1/4	18 1/4	20 1/8
International Business Mach.	450	349	390
Minneapolis-Hon.	70	50 1/8	59 7/8
National Cash Reg.	47	33 7/8	36 3/8
Radio Corp.	55 3/8	36 3/4	41 3/4
Raytheon	25 3/4	13 7/8	16 5/8
Robertshaw-F.	33 5/8	25 1/8	25 1/8
Sangamo Electric	32	25 1/2	31 7/8
Sperry Rand	29 5/8	21	25 1/2
Square D	55 1/4	40 1/2	52 1/4
Starrett, L.S.	50	40 3/4	44 3/4
Sylvania Elec.	49 7/8	41	43 1/2
Telautograph	37 1/2	25 1/2	32 7/8
Texas Inst.	16 7/8	10 1/8	12 1/2
Underwood	43 1/8	33	35 1/4

(1) Bid - Asked price, no sale.

American Stock Exchange:

	Price Range for 1955-56 Thru January 31		As of January 31
Security	High	Low	Last
Air Assoc.	12 3/4	7 3/4	9 5/8
American Meter	41	32	39 1/2
Benrus Watch	10 7/8	9 3/8	9 5/8 - 9 1/2 (1)
Breeze Corp.	9 3/8	5 3/4	6 7/8 - 6 5/8 (1)
Consolidated Electrodynamics	31 1/4	20	22 7/8
DuMont Labs.	17 1/8	8 1/2	8 3/4
ElectroData	17 7/8	10 3/8	14
Fairchild, C. & I.	37 1/4	21	22
Int'l Resistance	12 3/8	5	7 1/4
Lear Inc.	13 3/8	7 1/4	8 1/2
Nat'l Res. Corp.	33 1/4	17 3/8	18
Neptune Meter	34 7/8	21	31 1/2 - 30 1/2 (1)
New Haven Clock	4 1/8	2 1/4	2 1/2 - 2 3/8 (1)
Norden-Ketay	19 1/2	11 3/8	13 1/2
Pneumatic Scale	31	26 1/2	27 1/2 - 26 1/2 (1)
Servomechanisms	13 3/8	8 1/4	9 1/4
Wallace & Tiernan	26 7/8	19 1/2	21 1/2
Waltham Watch	2 7/8	1 3/8	2 1/2

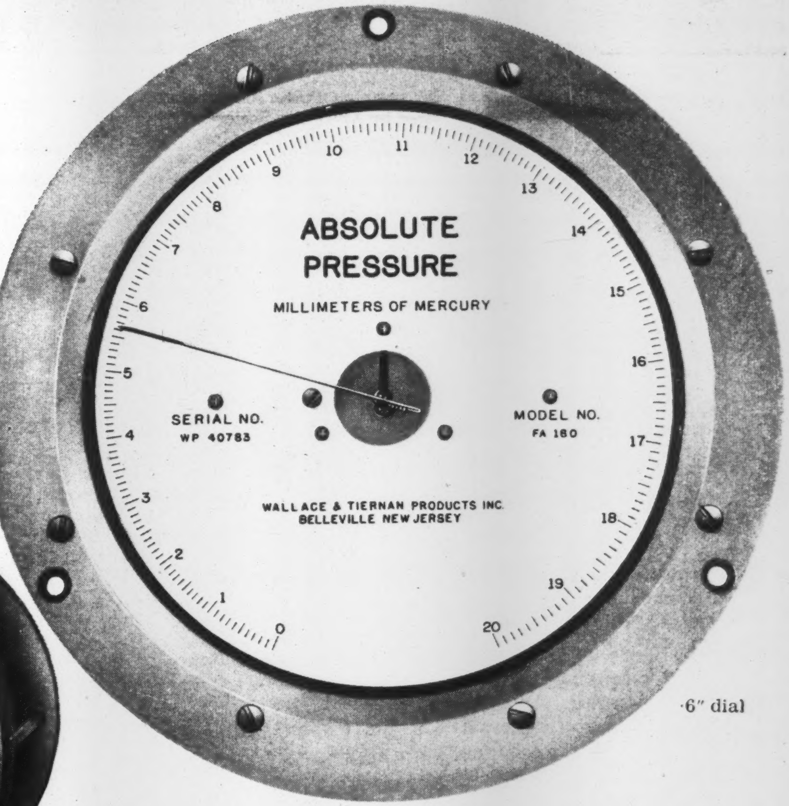
(1) Bid - Ask price, no sale.

ABSOLUTE PRESSURE INDICATOR

. . . FOR DEEP VACUUM WORK

Measures pressure
directly from
ZERO ABSOLUTE
to atmospheric

. . . swiftly and precisely


ABSOLUTE PRESSURE
MILLIMETERS OF MERCURY
SERIAL NO. WP 40783
MODEL NO. FA 180
WALLACE & TIERNAN PRODUCTS INC.
BELLEVILLE NEW JERSEY
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

6″ dial

ABSOLUTE PRESSURE
MM MERCURY
0
2
4
6
8
10
12
14
16
18
20

2¾″ dial

Used as a pressure indicator in any system employing a vacuum.

- All readings are relative to ZERO ABSOLUTE.
- Dial *reads directly.*
- Accurate to 1 part in 300 over full scale.
- Sensitive to 1 part in 500 in *all* ranges.
- No auxiliary indicator or corrections for ambient pressure changes required.
- Protected against sudden pressure surges.
- Ranges:
  - 0— 50mm Hg.
  - 0—100mm Hg.
  - 0—200mm Hg.
  - 0—410mm Hg.
  - 390—800mm Hg.
  - 0—800mm Hg.
- Dial Sizes: All ranges in either 2¾″ or 6″ dia.

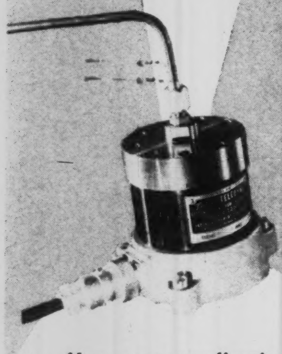
TYPE FA-160

For additional information on W&T Absolute Pressure Indicators, write today for Publication No. TP-28-A.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST., BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

A-102

For more information circle **31** on inquiry card.



. . . makes
AUTOMATION
Safely
AUTOMATIC

Teledyne
BONDED STRAIN GAGE
ELECTRICAL
PRESSURE TRANSMITTER

Has many applications in processing industries, 15 ranges up to 10,000 P.S.I.

Wherever high pressures are involved in automatic processes, there can always be an explosion hazard. Wherever this is true, the Teledyne will transmit pressure information to protected locations. The Teledyne is highly accurate and extremely durable. Bonded strain gage construction makes the Teledyne insensitive to vibration. Among its other features are high frequency response, linear output over full pressure range, and stainless steel pressure chamber for handling corrosives (including fuming nitric acid). Easily disassembled for clean-out and repairs.

PLEASE NOTE: Contact us for calibration service on Pressure Transducers. 0 to 25,000 P.S.I.

Write for Illustrated Literature

Taber
TABER INSTRUMENT
CORPORATION
SECTION 75
111 Goundry St., N. Tonawanda, N. Y.

For more information circle 32 on inquiry card.

INSTRUMENTS and AUTOMATION Events

For other computer Events see page 511.

March 26-27

ASM Instruments & Regulators Conference, Princeton University, Princeton, N. J.

April 1-5

Oil and Gas Power Conference sponsored by American Society of Mechanical Engineers, Hotel Jung, New Orleans, Louisiana.

April 3

Annual Symposium of the New Jersey Section, Inc. of the Instrument Society of America, Essex House, Newark, N. J.

April 5-6

Special Technical Conference on Magnetic Amplifiers, cosponsored by AIEE Committee on Magnetic Amplifiers, IRE Professional Group on Industrial Electronics and ISA Central New York Sec., Hotel Syracuse, Syracuse, N. Y. For information write Charles F. Spitzer, General Electric Co., Bldg. 3, Electronics Park, Syracuse, N. Y.

April 10-12

12th Annual Meeting and Metal Powder Show, Hotel Cleveland, Cleveland, Ohio.

April 11-13

1956 IRE 7th Region Technical Conference, Hotel Utah, Salt Lake City, Utah.

April 9-22

International Exhibition on Instrumentation-Automation, Oslo, Norway, sponsored by the Norwegian Industries Development Association (SNI) and Royal Norwegian Council for Scientific and Industrial Research (NTNF). For information write Studieselskapet for Norsk Industri, Munkedamsveien 53 B, Oslo, Norway.

April 10-11

Machine Design Conference, sponsored by the American Society of Mechanical Engineers, Bancroft Hotel, Worcester, Mass.

April 10-11

Symposium for Management on Applications of Analog Computers, Sponsored by Midwest Research Institute in cooperation with technical societies, Hotel Phillips, Kansas City, Missouri. For information write MRI, 425 Volker Blvd., Kansas City 10, Mo.

April 13-14

Tenth Annual Spring Television Conference sponsored by the Cincinnati Section of the Institute of Radio Engineers will be held at the Engineering Society of Cincinnati Building, 1349 E. McMillan St., Cincinnati, Ohio. For information write Reuben Nathan, Crosley Div., Avco Mfg. Corp., Glendale-Milford Rd., Evendale, Ohio.

April 16-17

Gas Turbine Power Conference, sponsored by the American Society of Mechanical Engineers, Hotel Statler, Washington, D. C.

April 19-20

Science Section of the Environmental Equipment Institute, Sheraton Hotel, Chicago, Ill. For information write H. F. Sander c/o Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 25-27

Symposium on Nonlinear Circuit Analyses II, Engrg. Societies Bldg., 33 W. 39th St., New York, N. Y., sponsored by Microwave Research Institute of the Polytechnic Institute of Brooklyn.

April 25

Symposium on "Control Systems Engineering—Electronic Controls In Industry" sponsored by the Wilmington Section, ISA. For information contact W. G. Schmick, Minneapolis-Honeywell Regulator Co., Orange St., Wilmington, Del.

April 26-27

Technical Conference on Electrical Recording and Controlling Instruments sponsored by AIEE, ASME and ISA cooperating, to be held at the Hotel Bradford, Boston, Mass. For information contact E. T. Davis, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

May 1-3

Electronic Components Symposium at the Auditorium of the U. S. Dept of Interior, Washington, D. C. For information write A. W. Rogers, Chairman, Signal Corps, Ft. Monmouth, N. J.

May 6-9

2nd National Flight Test Instrumentation Symposium sponsored by North Texas Section ISA & Flight Test Instrumentation Sub-Committee, Fort Worth, Texas.

May 8-11

Metals Engineering-AWS Conference sponsored by the American Society of Mechanical Engineers, Hotel Statler, Buffalo, N. Y.

May 14-16

8th Annual National Conference on Aeronautical Electronics, sponsored by the IRE, Dayton Biltmore Hotel, Dayton, Ohio. For information write P. O. Box 621, Far Hills Br., Dayton 9, Ohio.

May 14-17

Design Engineering Show, Convention Hall, Philadalphia, Pa. For information write Clapp & Poliak, 341 Madison Ave., New York, N. Y.

May 14-17

The Physical Society 40th Exhibition of Scientific Instruments and Apparatus, Royal Horticultural Society's Halls at Westminster. For information write Exhibition Secretary, 1, Lowther Gardens, Prince Consort Rd., London, S.W. 7, England.

May 17-18

7th Annual Conference on Fundamentals, Current Practice and Recent Advances in Industrial Engineering, Shoreham Hotel, Washington, D. C. For information write American Institute of Industrial Engineers, 145 N. High St., Columbus 15, Ohio.

May 14-19

International Colloquim on Spectroscopy, 6th annual meeting to be held at Amsterdam, Netherlands. Persons wishing to attend or contribute should correspond with the Secretary, Colloquim Spectroscopicum Internationale, Laboratorium voor Analytische Chemie, 125 Nieuwe Achtergracht, Amsterdam-C4, Netherlands.

May 21-24

Electronic Parts Distributors Show at the Conrad Hilton Hotel, Chicago, Ill. For information write S. I. Neiman, EPDIN, La Salle St., Chicago 2, Ill.

June 6-8

American Society for Quality Control 10th Annual Convention and Exhibit, Palais Du Commerce, Montreal, Canada. For information write Charles R. Kendel, Lamson & Sessions Co., 1971 West 85th St., Cleveland 2, Ohio.

November 26-30

Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

HAGEN
Synchronous motors

HAGEN
SYNCHRONOUS MOTORS
MODEL 50-01721
240 RPM C.W.
115 Volt
60 Cycle
7 Watts
ACTUAL SIZE

Speeds of 1800 to 1/6 RPM

Single direction — Reversible

Here is the most powerful, compact synchronous motor for its size. Ideal for use in industrial applications that require a motor of overall size that is between the "clock" and fractional horsepower types.

Hagen Synchronous Motors are precision built throughout. Construction features a die cast housing, hobbed pinions and gears and bronze bearings throughout. Laminated rotor construction produces exceptionally high torque.

Hagen Synchronous Motors are available in five models. Standard motors may be mounted in any position. Coils are available for 24, 115, 230, 440 and 550 volts. Write for complete descriptive literature and performance data.

HIGHLY DESIRABLE FOR USE IN:

TIMERS
CHART DRIVES
DISPLAYS
INSTRUMENTS

HAGEN

MAIL COUPON TODAY

HAGEN MANUFACTURING COMPANY, INC.
Dept. IAH-356, Moline, Illinois • Baraboo, Wis.

☐ Please send free Bulletin No. 1055 featuring Hagen Synchronous Motors

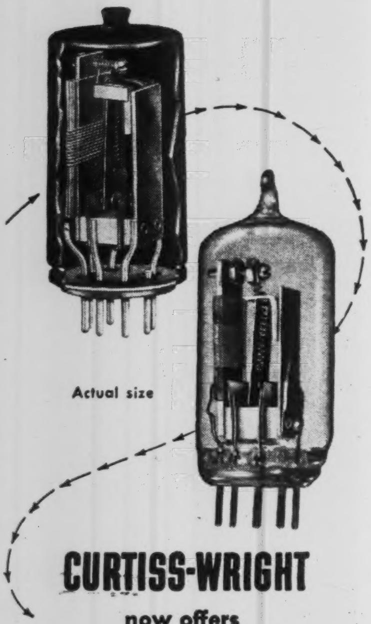
NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

For more information circle **33** on inquiry card.



CURTISS-WRIGHT
now offers
THE "SNAPPER" THERMAL TIME DELAY RELAY

Relied on for positive action and long life in scores of applications involving time delay in electrical circuits, the "SNAPPER," formerly produced by Elly Electronics Corp., is now a Curtiss-Wright product.

Single pole, double throw contact action eliminates chatter. These unique relays feature snap action, double throw, reliability, small size. They are adaptable to military and commercial applications. Time delay periods: preset from 3 seconds up. Envelope: metal, miniature (7 and 9 pin) or octal (8 pin). Glass, 9 pin only.

High-Low Differential Thermostat

The "SNAPPER" Thermostat is a single pole, double throw snap action temperature sensitive switch. Its snap action principle has been extended to provide a low differential thermostat with precision characteristics, at low cost.

Write for detailed data

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

For more information circle **34** on inquiry card.

INSTRUMENTS and AUTOMATION Films

When the publisher of *Instruments & Automation* was executive secretary of the ISA, he prepared a list of motion picture films of interest to groups in the field of instrumentation. The following list of films can be considered a supplement to this original list (obtainable from the ISA). Lists of other films can be obtained also from the ASME.

PROJECT TINKERTOY
Review: This film describes the modular redesign and automatic manufacture of an electronic circuit.
Source: Department of the Navy, Washington, D. C.
Avail: Loan

UNIVAC
Review: This film shows the principles, construction, and use of Remington Rand's Universal Automatic Computer.
Source: Remington Rand, 315 4th Ave., New York, N. Y.
Avail: Loan, probably, no fee mentioned.

EYE TO THE UNKNOWN Color, sound, 33 min.
Review: This film dramatizes early chemical analysis techniques, the entry of the mass spectrometer into the commercial field, and present applications of the mass spectrometer.
Source: Public Relations Dept., Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena 15, Calif.
Avail: Loan

THE ULTIMATE STRUCTURE B&W, sound, 40 min.
Review: The film covers three analytical X-ray techniques: Diffraction, Diffractometry and Spectroscopy.
Source: Vern W. Palen, Research & Control Instruments Division, North American Philips Co., Inc., 750 South Fulton Ave., Mount Vernon, N. Y.
Avail: Loan

ONE MORE STEP
Review: This film describes an automatically controlled punch press developed by the General Electric Company.
Source: General Electric Co., Schenectady 5, N. Y.
Avail: Loan, probably; no fee mentioned.

PIERCING THE UNKNOWN
Review: This film shows the development and use of IBM's large-scale defense computer.
Source: International Business Machines, 590 Madison Ave., New York, N. Y.
Avail: Loan, probably; no fee mentioned.

PROGRESS THROUGH CONTROLS
Color, 21 min.
Review: This film describes the automatic control field, including residential, processing, and aircraft applications.
Source: General Controls Co., Glendale, Calif. or Skokie, Ill.
Avail: Loan

TOOLING UP FOR PROFITS
Color, 16mm., 20 min.
Review: The film compares hand tool assembly methods with the startling production boost made possible by the application of Thor electric tools to the same operations at the Columbus, Ohio, plant of Armstrong Furnace Co.
Source: Thor Power Tool Co., Aurora, Ill. or branch offiices.
Avail: Loan to distributors and tool users.

THE ATOM GOES TO SEA
B&W, sound, 16mm., 12 min.
Review: This film tells the story of the atomic powered submarine, the Sea Wolf.
Source: General Electric film library, Schenectady, N. Y.
Avail: Loan, pay return postage.

PRODUCTION BAND MACHINING
16mm., sound, 30 min.
Review: The film goes through all the operations involved in machining a number of very different parts, stressing new machining concept of the contour cutting band machine.
Source: DoAll Co., 254 North Laurel Ave., Des Plaines, Ill.
Avail: Loan

A TRUE STANDARD
Color, 16mm., sound, 12 min.
Review: This film illustrates government activity in weights and measures adminstration . . . . providing accurate commercial measures.
Source: Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.
Avail: Loan

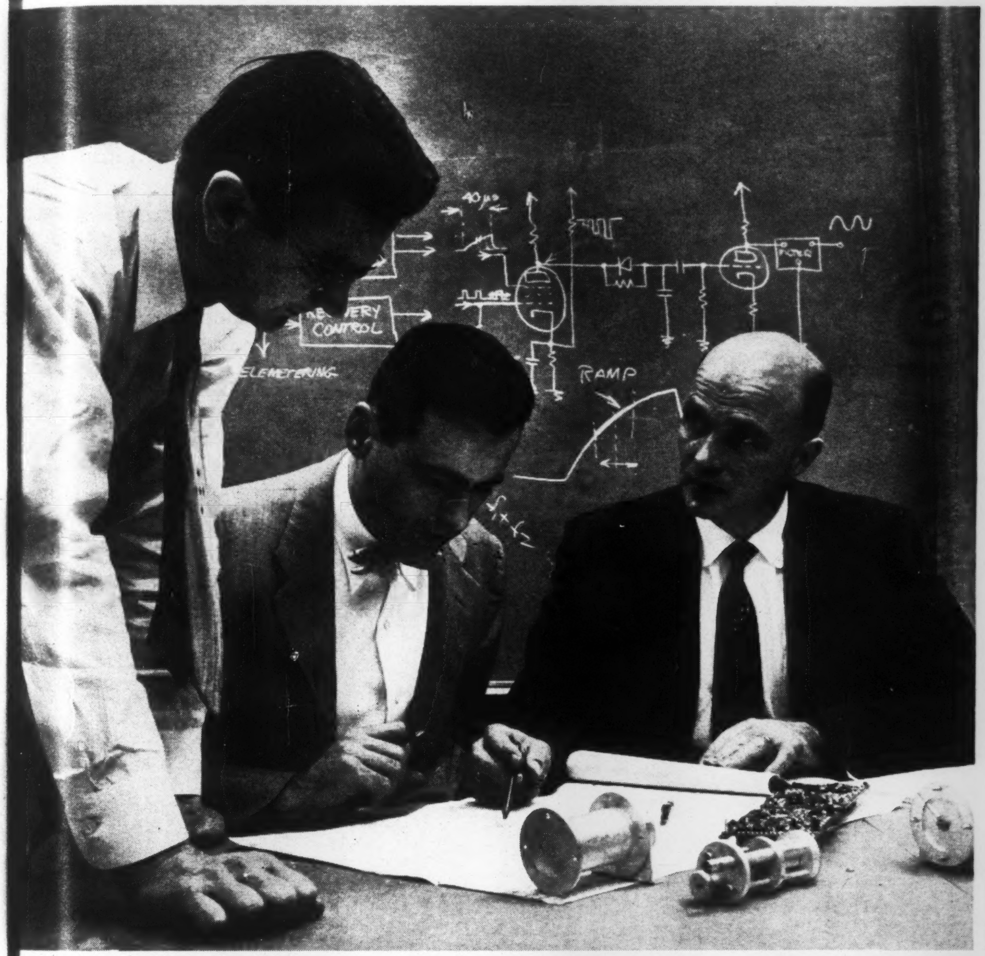
THE MELETRON STORY
Color, 16 mm., sound
Review: Presents functional characteristics of pressure actuated switches and highlights controlled accuracy in their manufacture.
Source: Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.
Avail: Loan, probably; no fee mentioned.

A STORY OF TELEVISION
14 min.
Review: The film relates the early efforts of Dr. Allen B. Du Mont

Continued on page 436

SCIENCE AND ENGINEERING

AT LOCKHEED MISSILE SYSTEMS DIVISION



Charles W. Goedecke, Electronic Design Group Engineer, Jay A. Cox, Electronic Research Engineer, and George L. Larse, head of Electronic Systems Development in the Flight Test Electronics Department, discuss important aspects of new electronic command decoding devices for missile guidance systems.

MISSILE ELECTRONICS

DATA TRANSMISSION LINKS SYSTEMS AND COMPONENTS

The advancement of missile systems technology can be measured to a great extent by increasing demands imposed on the ability of electronic systems and components engineers.

Electronic problems encountered in hypersonic flight, particularly at high ambient temperatures, require creative efforts and coordination of a high order from engineers in fields of radar, guidance, telemetry and instrumentation.

New developments at Lockheed Missile Systems Division offer a wide variety of assignments in the following fields:

Command guidance involving the development and application of radio frequency components, video amplifiers, pulse circuitry, decoding and control devices.

Automatic data processing equipment involving analog-to-digital conversion circuitry; electronic and magnetic storage components; pulse and timing circuitry of all types.

Data transmission and telemetry involving development and application of antennas, transducers, FM oscillators, VHF transmitters and receivers.

Those possessing keen interest in both systems and component development are invited to write.

Lockheed **MISSILE SYSTEMS DIVISION** *research and engineering staff*

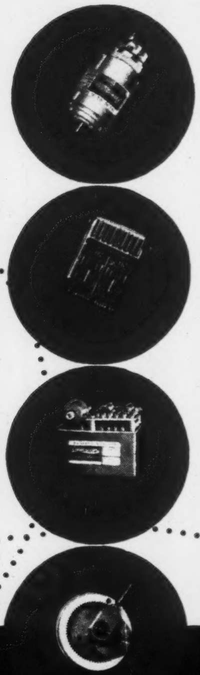
LOCKHEED AIRCRAFT CORPORATION **VAN NUYS • CALIFORNIA**

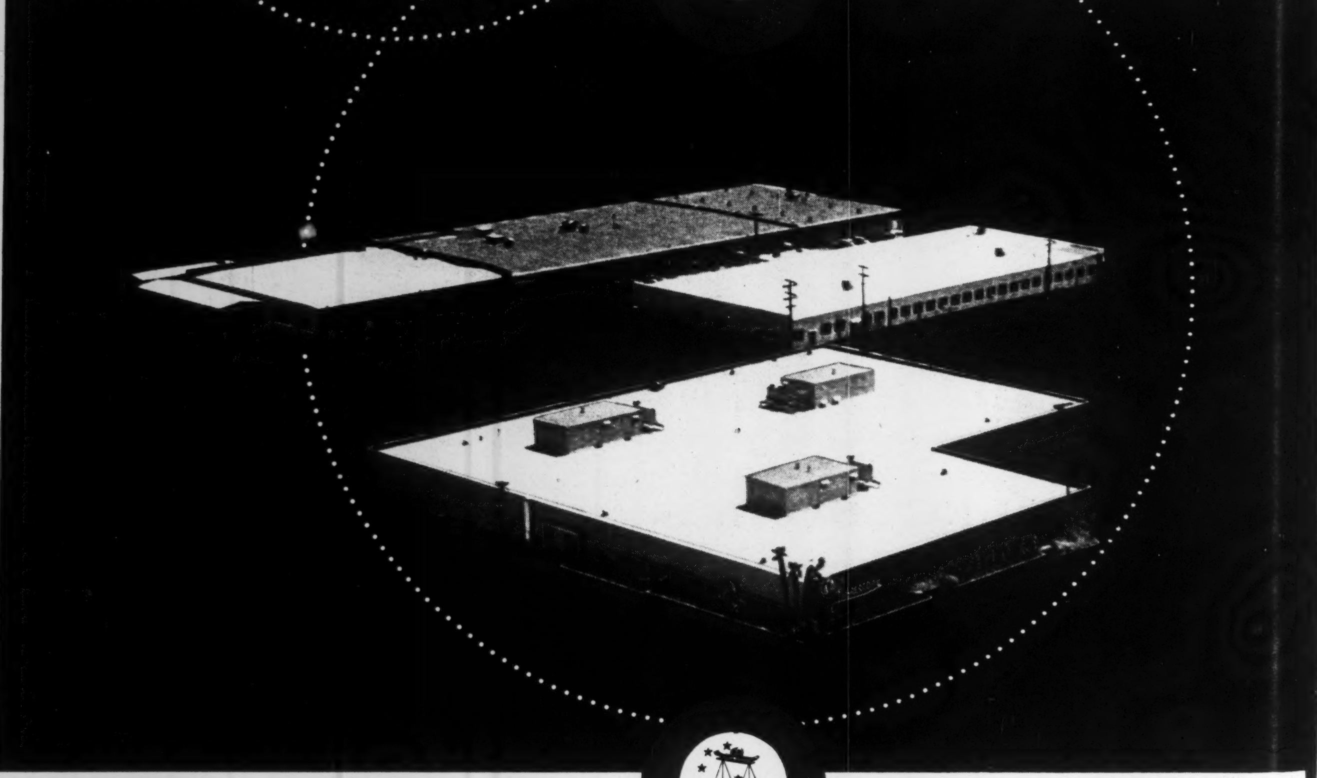
The Capacity for Achievement

Since 1937 Librascope has earned and achieved—on an ever expanding scale—a position of leadership in the design, development and manufacture of computers, automatic controls and data handling systems for military and industrial applications.

Librascope, through a unique combination of electronic, magnetic, mechanical and optical techniques, consistently demonstrates an outstanding facility for the production of precision instrumentation and devices.

The creative ability of an exceptional engineering staff and the production capacity of a superbly equipped 200,000 sq. ft. plant facility can be focused on *your* computer-control problem. Consult Librascope today.





ENGINEERS . . . *learn about Librascope's new creative "Project Development Teams". . . write Mac McKeague, Personnel Director*

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE

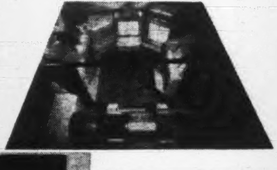
LIBRASCOPE, INC. · 808 WESTERN AVE. · GLENDALE · CALIFORNIA

For more information circle **35** on inquiry card.

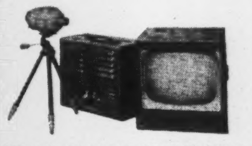
● Manufacturing ●● Manufacturing and product development ●●● Manufacturing, product development and research □●● Pilot manufacturing, product development and research

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
●●●	●●	●●	□●●	●●	●●●		●●	●●●	●●	●●	●●	●●●	Precision Mechanics, Optical Devices, Ceramics
●●●	●	●			●●●		●●●	●●	●	●●	●	●●●	Electrical Equipment and Components
●●●	●●	●●●	●●●		●●●		●	●●		●●●	●●	●●●	Electronics
	●●			●●●		●●●				●●●			Hydraulics, Liquids Processing, Heat Exchange
●	●		●●●		●					●			Television: Studio, Theatre, Business, Institutional, Industrial
●●●	●	●●	□●●		●●●	●●●	●●	●●		●●●	●	●●●	Instruments, Servos, Controls: Hydraulic, Pneumatic, Magnetic, Electronic
●●●	●		●●●		●●●		●			●●	●	●●●	Aircraft and Missile Guidance, Control, Simulation
●●●	●	●	□●●		●●●					●●●		●●●	Automatic Computers and Components
●●●	●	●●	●●●		●●			●		●			Radar, Microwave, Ultrasonics
	●●●		□●●				●●	●●●	●●●		●●●		Motion Picture and Audio Equipment
●●●				●●						●●		●●●	Nuclear Power Components and Controls
●●●			●●●	●●●	●●●	●●●				●●●		●●●	**SYSTEMS ENGINEERING**

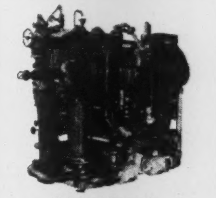
Librascope Desk-Size Computer



Link Aviation
F-89D Jet Simulator



GPL Industrial-Institutional TV System



Griscom-Russell
Shipboard Distilling Plant

Askania Electro-Jet
Power Package

SYSTEMS ENGINEERING

The GPE Companies are leaders in that small, select group in American industry which is broadly qualified to develop and produce the systems needed today for defense and industry. GPE leadership accounts for some of the most advanced systems in use in business, television, aviation, marine, steel, oil, power and other industrial fields.

In Systems Engineering, advanced capacities and resources are prerequisite. Yet, no matter how highly advanced, they are insufficient if limited to a few areas. And beyond that, success requires the application of such *balanced competences* at every stage—beginning with research and extending all the way through development, production, and final testing.

The following basic characteristics and methods of operation of the GPE Companies explain GPE successes in systems work:

- *the exceptional engineering acumen of more than 2500 GPE scientists, engineers and technicians working in depth in the wide range of advanced capacities indicated in the chart above;*
- *the extensive research, development, manufacturing and testing resources of the GPE Companies;*
- *the GPE operating policy, Coordinated Precision Technology, which inter-relates all relevant GPE engineering, research, and production skills and resources;*
- *unremitting insistence on highest quality on the part of every GPE Company, every step of the way.*

No GPE Company is limited by the boundaries of its own specialties. Behind each engineering group working on a specific problem in one GPE company stands the whole group of GPE scientists, engineers and technicians with the answers—or the knowledge that will find the answers—to questions underlying and related to that problem.

To the customers of GPE Companies this means that the concept and development of equipment, components and systems are not restricted or distorted by traditional allegiance to specific competences. The five systems illustrated, while products of different GPE companies, are all examples of the consistent application of balanced competences, achieved through GPE coordination.

For brochure describing GPE Coordinated Precision Technology and the work of the GPE Companies, or help on a specific problem, write: General Precision Equipment Corporation, 92 Gold Street, New York 38.

GENERAL PRECISION EQUIPMENT CORPORATION

THE GPE PRODUCING COMPANIES

Ⓘ KEARFOTT COMPANY, INC. Ⓘⓘ INTERNATIONAL PROJECTOR CORPORATION ⓘⓘⓘ BLUDWORTH MARINE
IV GENERAL PRECISION LABORATORY INCORPORATED V THE GRISCOM-RUSSELL COMPANY VI LINK AVIATION, INC.
VII SHAND AND JURS CO. VIII THE HERTNER ELECTRIC COMPANY IX THE STRONG ELECTRIC CORPORATION
X J. E. McAULEY MFG. CO. XI ASKANIA REGULATOR COMPANY XII AMPRO CORPORATION XIII LIBRASCOPE, INCORPORATED

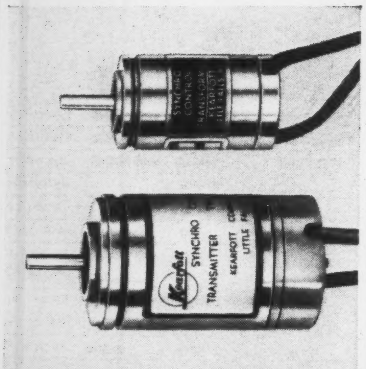
For more information circle **36** on inquiry card.

SIZE 8 (R1000 Series)

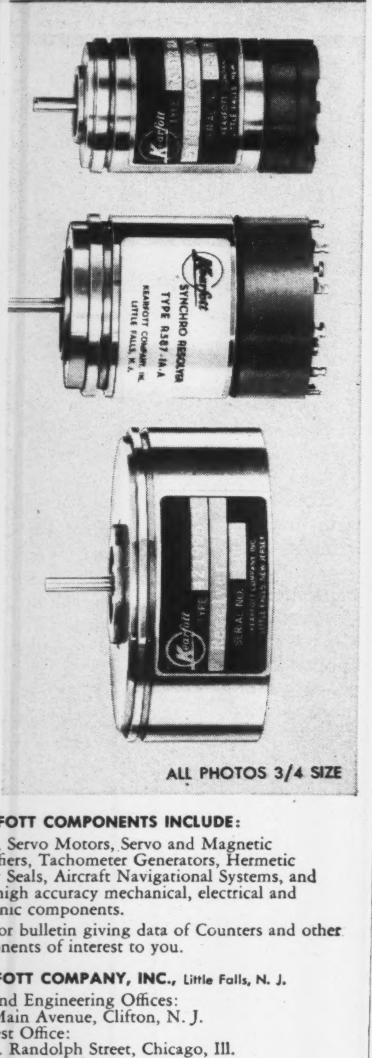
.750 x 1.240 inches, weighs 1.75 oz. Available as transmitters, control transformers, resolver and differentials. Max. error from EZ 10 minutes.

SIZE 11 STANDARD (R900 Series)

1.062 x 1.766 inches, weighs 4 oz. Available as transmitters, control transformers, repeaters, resolvers and differentials for 26V and 115V applications. Max. error from EZ 10 minutes.



SYNCHROS STANDARD AND SPECIAL


Kearfott SYNCHRO RESOLVER TYPE R587-1M-A KEARFOTT COMPANY INC. LITTLE FALLS, N.Y.
SERIAL No.
ALL PHOTOS 3/4 SIZE

SIZE 11 SPECIAL (R500 Series)

Same basic dimensions and applications as standard Size 11 Synchros. Conforming to Bu. Ord. configurations with max. error from EZ of 7 minutes.

PRECISION RESOLVER (R587)

Size 15. With compensating network and booster amplifier, provides 1:1 transformation ratio, 0° phase shift, 5 minute max. error from EZ. Tangent generator explanation.

"PANCAKE" SYNCHROS

2.478 x 1.078 inches, weighs 11 oz. Available as transmitters, control transformers, resolvers, differentials and linear induction potentiometers. Max. error from EZ 2½ minutes. Suitable for gimbal mounting.

All these Kearfott Synchros are constructed of corrosion resistant materials, thus enabling them to be operated under adverse environmental conditions.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Send for bulletin giving data of Counters and other components of interest to you.

Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., Little Falls, N. J.
Sales and Engineering Offices:
1378 Main Avenue, Clifton, N. J.
Midwest Office:
188 W. Randolph Street, Chicago, Ill.
South Central Office:
6115 Denton Drive, Dallas, Texas
West Coast Office:
253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **37** on inquiry card.

FILMS

—*Continued from page 432*

to develop a long-life, cathode-ray tube at reasonable cost.

Source: Edward W. Allen, Jr., Manager of Publicity, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

Avail: Loan, probably; no fee mentioned.

IRON ORE FROM CERRO BOLIVAR
Color, sound

Review: The film shows original drilling operations, construction of railroad, camps and dock . . . . . to the first trainload of ore.

Source: U. S. Steel Corp., 525 Wm. Penn Place, Pittsburgh, Pa.

Avail: Loan

ORIFICE TESTS IN LARGE LINES
Color, sound

Source: Ralph H. Clemons, Jr., Daniels Orifice Fitting Co.

Avail: Loan

RELAYS ON TRIAL
Color, 16mm., sound, 20 min.

Review: This film shows the equipment used and the procedures necessary for qualifying relays to military specifications.

Source: Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

Avail: Loan

STEEL TUBES FOR INDUSTRY
Color, 16mm., sound, 20 min.

Review: The largest drawbench in the West is shown in action, and animated drawings show the details of tube drawing and tube reduction.

Source: Pacific Tube Company, 5710 Smithway Street, Los Angeles 22, Calif.

Avail: Loan

FILM ON SHELL'S PIPELINE
Color, sound

Review: Film shows the various operations at Shell's Wood River-Chicago multiple products pipeline, and demonstrates how time and space have been conserved by the modern methods used to blend, measure and transport petroleum.

Source: Proportioneers, Inc., 345 Harris Ave., Providence, R. I.

Avail: Loan, probably; no fee mentioned.

METALLURGY IN MINIATURE
Color, 16mm., sound, 15 min.

Review: This film explores the mysteries of the metals in the search for a new alloy.

Source: Association Films, 347 Madison Ave., New York 17, N. Y.

MECHANICAL ARM
Color, 16mm., 15 min.

Review: This film illustrates the operation of a typical General Mills remotely controlled mechanical manipulator that can handle loads up to

WHY ENGINEERS FEEL AT HOME AT ROCKETDYNE

First and foremost, ROCKETDYNE talks your language—and understands it too. Your associates and supervisors here are professional people like you. They respect your status, your thinking, your ideas and your interest in technical advancement.

ROCKETDYNE will encourage you to choose the field that is most satisfying and rewarding . . . truly best for you. This is possible because its activity includes the full range of rocket engine development from preliminary design to field testing and production . . . because its programs include development of the largest liquid-propellant rocket engine in the Western World . . . because it has contracts with all branches of the Armed Services and the guided missile industry for broad variety of rocket engine types and sizes.

It may surprise you to know you can qualify for a career at ROCKETDYNE *with or without specific rocket engine experience!* Engineering experience in heating and ventilating, hydraulics, pumps, turbines, combustion devices, controls, dynamics, structures and instrumentation are just a few of the related fields that could open your future at ROCKETDYNE.

ROCKETDYNE's design and manufacturing center and its nearby test laboratory house complete, advanced facilities . . . the vital tools you need to meet the challenges of rocket engine development.

ROCKETDYNE is North American's rocket engine division. It has just moved into new ultra-modern headquarters in Canoga Park, located in the beautiful West San Fernando Valley of Los Angeles. This area is famous for its fine residential sections, modern shopping-center convenience, varied recreational and entertainment facilities. Any point in the San Fernando Valley is just minutes drive from the beaches, and the weather is pleasant all year around. Many engineers are interested in advanced courses offered by fine schools like UCLA, USC and Cal Tech, all within a short drive from our headquarters.

THESE POSITIONS NOW OPEN AT ROCKETDYNE:

DESIGN & DEVELOPMENT ENGINEERS
Mechanical, Chemical, Electrical, Aeronautical, Standards, Structural and Stress. For rocket engine components and systems design or development. Turbine, pump, controls and combustion device experience preferred.

TEST ENGINEERS
Experienced on engine systems, combustion devices, turbines, pumps and engine instrumentation.

EQUIPMENT DESIGN ENGINEERS
Electrical, mechanical, structural, industrial. For design of facilities, specialized test, and handling equipment.

DYNAMICS ENGINEERS
To analyze rocket engine control systems utilizing electronic analog and digital computers, B.S., M.E., or B.S.E.E. necessary. Prefer advanced degree. Experience in servomechanisms, systems analysis desired.

THERMODYNAMICIST
To analyze, design and develop high speed subsonic and supersonic turbines. Jet engine or industrial steam turbine experience desired.

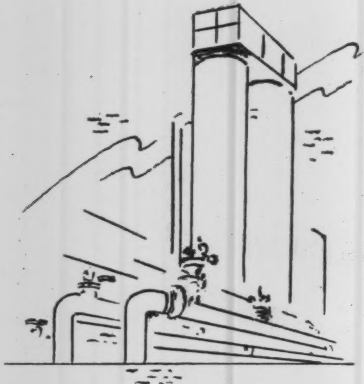
WEIGHT ENGINEERS
ELECTRONICS TECHNICIANS
SPECIFICATIONS ENGINEERS
ENGINEERING DRAWING CHECKERS

Write Mr. Grant Baldwin, Rocketdyne Engineering Personnel, Dept. 596-IA, 6633 Canoga Ave., Canoga Park, Calif.

ROCKETDYNE

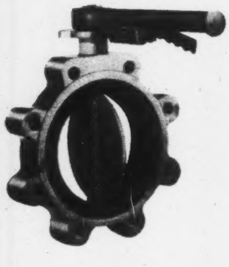
A DIVISION OF NORTH AMERICAN AVIATION, INC.

BUILDERS OF POWER FOR OUTER SPACE



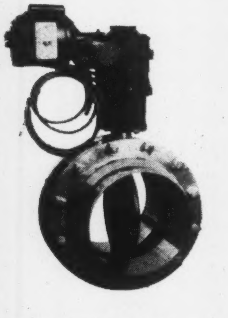
KEYSTONE VALVES DO EVERY JOB BETTER!

Standard valve with lever handle

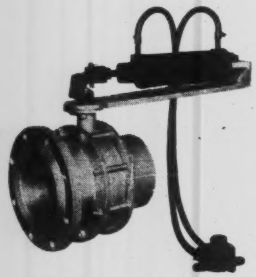


Lug-Type valve with lever handle

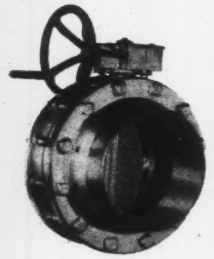
Standard valve with diaphragm actuator



Standard valve with electric actuator



Standard Valve with hydraulic actuator



Standard valve with gear actuator

SIZES, 1" THROUGH 48". WRITE FOR COMPLETE INFORMATION

KEYSTONE VALVE CORP.

KEYSTONE VALVE CORP.

P. O. Box 6716 Telephone JA 3-1623 Houston, Texas

Representatives in principal cities throughout the world.

The ORIGINAL Design

Bubble-Tight Closure ● No Gaskets Required ● Securely Fastened Seats

For more information circle **38** on inquiry card.

FILMS—CONTINUED

1,000#, but is useful for small assembly operations.

Source: General Mills, Inc., Mechanical Div., Engineering Research & Development Dept., 2003 E. Hennepin Ave., Minneapolis 13, Minn.

Avail: Loan-General Mills will furnish a speaker; allow 1 month notice.

THE PULSE OF TIME

B&W, 16mm., sound, 10 min.

Review: The story of time from the first sun-dials to the modern, ball-bearing, self-winding movements.

Source: Association Films, 347 Madison Ave., New York 17, N. Y.

Avail: Loan, pay transportation costs.

WHAT MAKES A FINE WATCH FINE?

B&W, 16mm., sound, 20 min.

Review: This film presents a visit to a factory, where skilled employees work with watch parts small as dust flecks and with tools that can bore through a hair.

Source: Association Films, 347 Madison Ave., New York 17, N. Y.

Avail: Loan, pay transportation costs.

THE STORY OF METAL BELLOWS

B&W, 16mm., sound, 30 min.

Review: The film shows a disc of metal formed into a completed bellows, and illustrates bellows applications in temperature regulators.

Source: E. D. Rogers, Adv. Mgr., Fulton Sylphon Co., Knoxville 4, Tenn.

Avail: Loan, pay return postage.

ULTRASONIC INSPECTION

Color, sound, 10 min.

Review: This film describes the development, theory, operation, and application of the Sperry Ultrasonic Reflectoscope for non-destructive testing of metals; results recorded automatically.

Source: Sperry Products, Inc., Danbury, Conn.

Avail: Loan

READY FOR SEA

Color, 16mm., sound, 13 min.

Review: This is a case history of the production and testing of electronic equipment for use on board ship.

Source: Public Relations Dept., Raytheon Mfg. Co., Waltham 54, Mass.

Avail: Loan

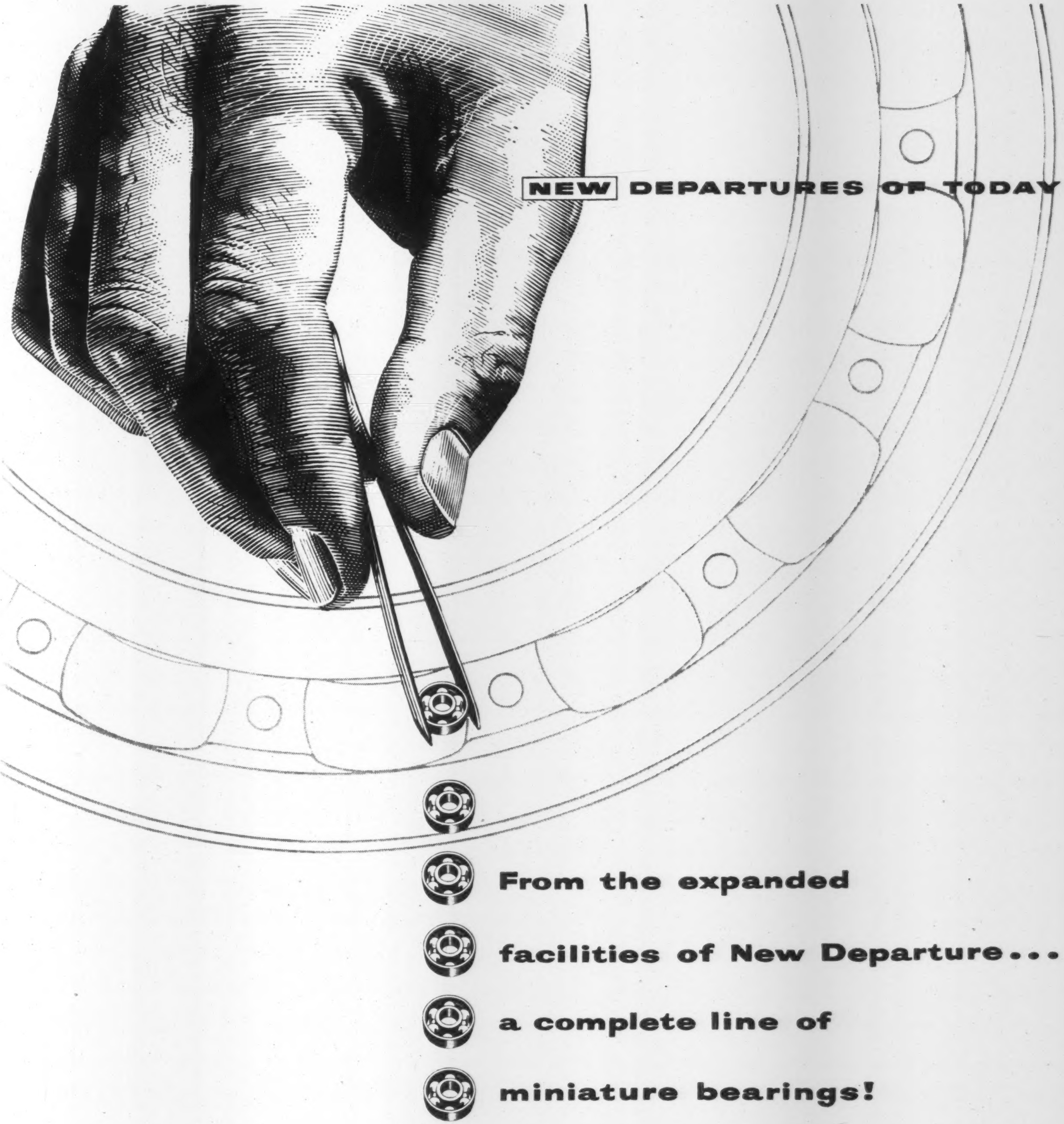
5,000 YEARS OF FORGING

B&W, 16mm., sound, 20 min.

Review: This film deals with the history and the mechanical progress of forging from its inception by primitive man to today's modern methods.

Source: Henry J. Zellweger, Advertising Manager, Utica Drop Forge & Tool Corp., Utica 4, N. Y.

Avail: Loan, pay transportation cost.



From the expanded facilities of New Department . . . a complete line of miniature bearings!

The most exacting needs of today's precision industries are met by New Departure's complete line of miniature ball bearings, ⅜″ (.375″) outside diameter and smaller.

Made with extreme accuracy, these tiny steel "jewels" are assembled, torque-tested, and packed in pressurized, atmosphere-conditioned areas of surgical cleanliness, assuring performance and dependability of the highest order.

For full information about miniature bearings, or for engineering help on your bearing problems, contact New Departure, Division of General Motors, Bristol, Conn.

GM
GENERAL MOTORS

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL

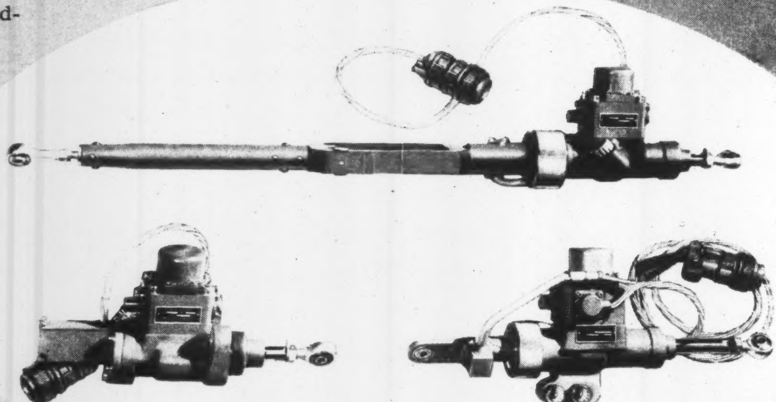
For more information circle **39** on inquiry card.

From MOOG... Integrated Electro-Hydraulic Servo Actuator Units

▶ Industry today has many new requirements for special actuators for use in high-performance electro-hydraulic servo systems. The Moog Valve Company, Inc., as a leading servo valve manufacturer, recognizes a need for these components to be supplied as integrated valve-actuator assemblies. Such complete actuator packages offer the advantages of a comprehensive custom design including reduced overall complexity and minimum size and weight.

These package units available from Moog include an actuating cylinder, an electro-hydraulic servo valve, and a feedback sensing device. In combination with a suitable electronic amplifier they provide control of actuator displacement as a function of input signal. Overall performance is characterized by high dynamic response, linearity, and excellent resolution.

To meet special requirements, assemblies can be provided which include such auxiliary devices as shut-off or by-pass solenoid valves, force limiting relief valves, and piston locks.



MOOG

MOOG VALVE CO., INC. PRONER AIRPORT, EAST AURORA, N. Y.

For more information circle **40** on inquiry card.

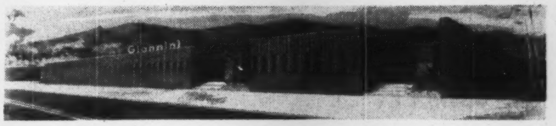
New Plants and Mergers

BALDWIN-LIMA-HAMILTON CORP., Phildelphia, announces a new plant is now under construction at Waltham, Mass. The Electronics and Instrumentation Division—including the O. S. Peters Co. (Washington, D. C.), Ruge-de-Forest, Inc. (Cambridge, Mass.), Sonntag Scientific Corp. (Greenwich, Conn.), and Testing Facilities Division (Eddystone) will be moved to the new structure.

BYRON JACKSON DIV., BORG-WARNER CORP. announces that construction has started on their new one million dollar electronics plant at Santa Ana, Calif. The 65.000 sq ft building will combine operations now performed in four plants in Pasadena.

HAMMEL-DAHL CO., Providence, R. I., announces the appointment of the E. B. Miller Co., 6636 Clayton Road, St. Louis 17, Missouri, as their new Sales Representatives in that territory.

FENWAL, INC., Ashland, Mass., has added 100,000 sq ft of manufacturing space to its facilities, announces *Carl W. Walter*, president. The addition doubles Fenwals' manufacturing space.

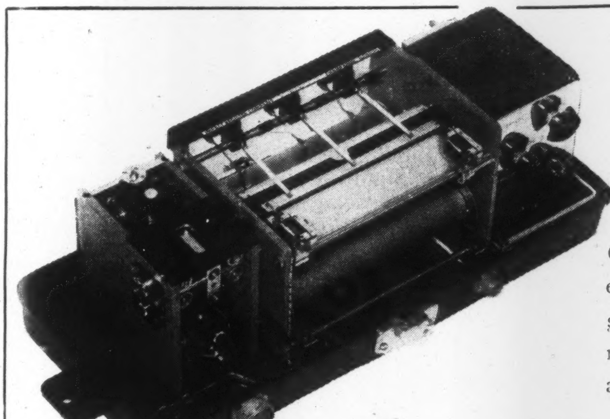


GYRO DIV., G. M. GIANNINI & CO. has been moved to Pasadena, Calif., announces *W. I. Shevell*, Div. Mgr.

NON-LINEAR SYSTEMS, INC., Del Mar, Calif., has appointed the J. T. Hill Co., San Gabriel, Calif., as representative in the Calif., Arizona and Nevada area, announces *Arthur M. Watson*, sales mgr.

DAYSTROM, INC., announces purchase of 20 acres of land on Mountain Ave., Berkeley Heights, N. J., for a new executive office building.

MEASUREMENTS CORP., subsidiary of Thomas A. Edison Inc., announces the acquisition of Linear Equipment Laboratories, Inc. The company has been located in Copiague, L. I., N. Y. but will move to the new location at Boonton, N. J.



THREE COMPONENT ACCELEROMETER

One of the finest, direct-recording, mechanical accelerometers built. Thirty-five years' experience have gone into the design of this ruggedly built, accurate and dependable instrument. Available in one and two component accelerometers.

AVAILABLE WITH THE FOLLOWING FEATURES:

A. **Accelerometer Elements**
  Wide range of frequency and G.
  Elements are ball bearing mounted for minimum hysteresis loss.
  Accuracy is 2% of full scale.
  All elements are linear and are damped.

B. **Recording Chart**
  7" Wide, wax coated, 2" trace for each component.
  Instantaneous records — no developing required.

C. **Chart Drive**
  400 Cycle—115 volt synchronous for direct or remote operation.
  60 Cycle—115 volt synchronous for direct or remote operation.
  Spring driven motors for 8, 16 or 30 day operation.

D. **Chart Speed**
  ½"/hour to 60"/minute in single or two speed selection.
  Wider ranges furnished on request.

E. **Recording Styli**
  Heat or pressure recording type, sapphire tipped.

F. **Usage**
  Package testing, impact testing, riding qualities of all types of vehicles for land, sea, aircraft and missile work.

G. **Size and Weight**
  16"x8"x8"—Weight, 18 pounds.

For further details write:

Impact Register Company, P. O. Box 445, Champaign, Ill.

MAKERS OF VGTA FLIGHT RECORDERS, IMPACT REGISTERS AND RIDE RECORDERS

For more information circle **41** on inquiry card.

FACTS YOU SHOULD KNOW
ABRASIVES DIVISION
ELGIN NATIONAL WATCH COMPANY
ELGIN

FREE BOOKLET

... tells how to judge diamond quality.

SEND FOR YOUR COPY TODAY!

Most up-to-date information available. Helps you use diamond better, more efficiently. Serves as guide when buying or using diamond.

Elgin Diamond is the standard for industrial diamond quality. Only Elgin offers this Master Comparison Gage to let you check your own diamond for grading and purity.

ABRASIVES DIVISION, DEPT. T

ELGIN NATIONAL WATCH COMPANY

ELGIN ILLINOIS

For more information circle **42** on inquiry card.

Berkeley news notes

free data file

"An Introduction to the Application of Electronic Analog Computers"

by Hugo Martinez

Presented at National Conference on Industrial Hydraulics October 27, 1955

Data File 121

Discusses use of simulation for solution of a large variety of problems, particularly in systems design and engineering. Presents mathematical background, various types of simulation devices, with a complete presentation on electronic analog simulation equipment. Includes references and bibliography.

For your free copy, please address Dept. B-3.

Berkeley

division of Beckman Instruments Inc.
2200 Wright Ave., Richmond 3, Calif.

88

For more information circle **43** on inquiry card.

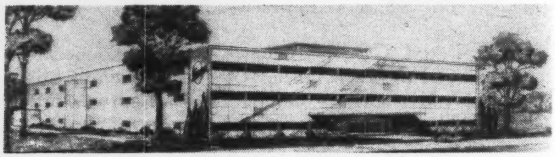
PLANTS—CONTINUED

CONOFLOW CORP., Philadelphia, Pa., announces the appointment of the E. K. Graham Co. as sales agent in the Houston-Gulf Coast territory.

VARIAN ASSOCIATES., Palo Alto, Calif., announces the development and production group formerly known as Special Products Div. will henceforth be known as Instrument Div.; Division sales are now running at annual level of over $1,500,000.

PERKIN ENGINEERING CORP., El Segundo, Calif., has appointed Instrument Associates, 1315 Massachusetts Ave., Arlington 74, Mass. their DC power supply representative in Maine, New Hampshire, Mass., Rhode Island and Conn., announces *Philip Diamond*, pres.

KEARFOTT CO., INC. will construct a new Engineering Sales building opposite the present home offices and production plants in Little Falls, N. J., announces *Donald W. Smith*, president.



TEXAS INSTRUMENTS, INC. has entered in an agreement to purchase the business and assets of the Burlington Instrument Co., announces *J. E. Jonsson*, president of Texas Inst.

HELIPOT CORP., South Pasadena, Calif., announces groundbreaking soon for a new $2 million plant at Newport Beach, Calif.

ROBERTSHAW-FULTON CONTROLS CO. announces establishment of a unified engineering department at the St. Louis plant to facilitate quality control functions and product improvement.

SORENG PRODUCTS CORP. AND A-P CONTROLS CORP. have merged to form Controls Corporation of America announce *Louis Putze*, president of Soreng, and *Roy W. Johnson*, president of A-P Controls.

CARL A. BAYS AND ASSOCIATES, INC. announce acquisition of the Hayes Scientific Appliances Company of Urbana, Ill. Operations will be combined as the Urbana Engineering Products Division of the Company.

COMBUSTION CONTROL DIVISION, ELECTRONICS CORPORATION OF AMERICA announces their new address is 14057 Madison Avenue, Cleveland 7, Ohio.

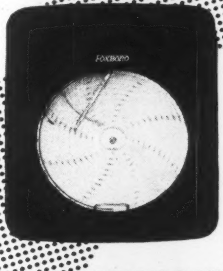
WARD K. STALLINGS CO., Atlanta, Ga., (manufacturers' reps.) announces that *Roy W. Freeman* is joining the firm.

ACE ELECTRONICS ASSOCIATES has moved to new quarters at 193 Dover St., Somerville 44, Mass., announces *Aaron Solomon*, president.

GENERAL TRANSISTOR CORP., has moved into a new plant at 130-11 90th Ave., Richmond Hill, N. Y.

This potentiometer
has no slidewire
In DYNALOG Instruments, a simple, radio-type variable capacitor replaces the troublesome slidewire — gives unmatched smoothness of balancing.

STEPLESS CAPACITY-BALANCING
ELIMINATES STANDARDIZING!



DYNALOG'S EXCLUSIVE BALANCING ACTION

- no slidewire
- no batteries
- no standardizing
- no gears, cables, etc.
- no high-speed reversing motor

Here's the potentiometer that's *never* "off process" for standardizing. It requires none! The Dynalog's advanced, stepless-balancing design eliminates dry cell, provides *direct, uninterrupted* evaluation of the measured variable with sustained high accuracy.

Dynalog* design eliminates slidewire maintenance and motor servicing too! A simple, variable capacitor and positive magnetic drive provide smooth, continuous balancing action . . . instant response without wear. There are no fast-moving parts . . . no gears, cables, or complicated mechanisms. Only five moving parts, including the recording pen!

Dynalog Instruments are available for use with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable. For complete details, write for Bulletin 427. The Foxboro Company, 463 Neponset Ave., Foxboro, Mass., U.S.A.

**Reg. U. S. Pat. Off.*

FOXBORO DYNALOG

Reg. U.S. Pat. Off.

ELECTRONIC INSTRUMENTS

For more information circle **44** on inquiry card.

Standard Chrono-Tach shown front and center in "deep freeze" engine testing laboratory. (Courtesy of Thompson Products, Inc.)

LOOK TO THE INSTRUMENTS USED FOR DEPENDABLE END RESULTS

In almost every research and testing laboratory the information needed to obtain a specific end result depends upon knowing, to an accurate degree, the speed of revolving shafts, motors, governors or other rotating equipment.

And it's a well-known fact that the end result can be no more reliable than the instruments that are used.

That's why the Standard Chrono-Tachometer plays such an important role in so many industrial, governmental and educational laboratories. Built for *continuous* service, it is a test instrument of extreme accuracy, invaluable wherever the precise measurement of speed of rotation is required.

Write for Engineering Bulletin #218

THE **Standard**
ELECTRIC TIME COMPANY
93 Logan Street • Springfield 2, Massachusetts

HOSPITAL SIGNALLING | ANALOGUE COMPUTERS | ELECTRIC CLOCK SYSTEMS | LABORATORY PANELS | PRECISION TIMERS and TACHOMETERS

For more information circle **45** on inquiry card.

People IN THE NEWS

MANNING, MAXWELL & MOORE, INC., announces election of *J. Robert Kelley* as president, succeeding *Hamilton Merrill.*

J. R. Kelley
MM & M

Morris F. Ketay
Norden-Ketay

NORDEN-KETAY president, *Morris F. Ketay*, received the "Gano Dunn Medal" awarded by Cooper Union Alumni for Outstanding Professional Achievement.

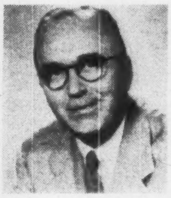
KELLOGG SWITCHBOARD & SUPPLY DIV., INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., announces appointment of *W. G. Vance* and *J. T. Robertson* as Assistant Sales Managers, and *W. C. Hopper* as North Eastern Division Manager.

G. M. GIANNINI & CO., INC., Pasadena, Calif., announces appointment of *William S. Oman* as Division Manager of the newly formed Controls Division.

CONSOLIDATED ELECTRODYNAMICS CORP., Pasadena, Calif., has appointed *Gerald P. Foster* as chief, services section, announces *Harry E. Burke, Jr.*, Systems Div. director.

Joseph H. Lancor, Jr., engineering vice-president, announces appointment of *Francis T. Greenup* as assistant chief product engineer, and *Richard B. Mulock* as staff assistant, product engineering.

WESTON ELECTRICAL INSTRUMENT CORP., Newark, N. J., has appointed *Russel A. Schlegel* as manager of industrial product sales, and *John D. MacNamara* as field sales manager, announces *W. H. Steinkamp*, vice-pres. sales.


R. A. Schlegel
Weston

J. D. MacNamara
Weston

HELIPOT CORP., South Pasadena, Calif., announces the appointment of *Harry Schmidt* as assistant to the sales manager, and *Don Jones* and *Hank Crout* as regional sales managers.

NORTH AMERICAN AVIATION has appointed *David G. Soergel* as manager of the Applications Dept. of Autonetics, announces *John R. Moore*, general manager.

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

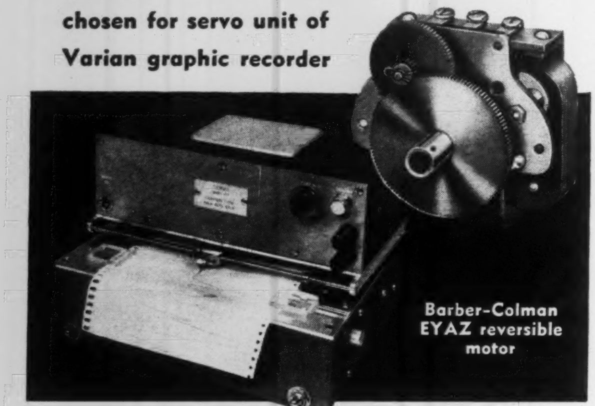
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.

For more information circle 46 on inquiry card.

BARBER COLMAN

Small Motors

chosen for servo unit of Varian graphic recorder



The Varian Model G-10 Recorder, made by Varian Associates of Palo Alto, California, is designed to provide maximum versatility for a wide variety of product testing and research applications. The chart pen is positioned by a self-balancing potentiometer type servo employing a Barber-Colman EYAZ reversible motor. For highly dependable actuation of your instruments or products, too, there is a wide selection of Barber-Colman small motors up to 1/20 hp. Unidirectional, synchronous, and reversible . . . with or without gearing . . . open or enclosed. Write for Catalog F-4271-6.

Barber-Colman Company

Dept. C, 1215 Rock St., Rockford, Ill.

For more information circle 47 on inquiry card.

NEW IDEAS

NEW PRODUCTS

NEW PROFITS

in conveying, data handling, gauging, testing, weighing, hydraulic and pneumatic controls, motors, drafting equipment, special machinery at the

1956

GERMAN INDUSTRIES FAIR

in HANOVER, West Germany, April 29th-May 8th

3,200,000 sq. ft. of business opportunities staged by four thousand exhibitors.

For information, tickets, hotel reservations and **FREE FACT-FILLED PAMPHLET** call WIsconsin 7-0727 or write the

GERMAN-AMERICAN TRADE PROMOTION OFFICE

350 Fifth Avenue **New York 1, N. Y.**

Twenty-minute, 16-mm sound color film on the GERMAN INDUSTRIES FAIR available for group showing.

For more information circle 48 on inquiry card.

PEOPLE—CONTINUED

WEKSLER THERMOMETER CORP. announces the election of *Edward P. Dobrin* as president and *Harry Weksler*, founder, as Chairman of the Board.

E. P. Dobrin
Weksler

John J. Wilber
Bailey Meter Co.

BAILEY METER CO., Cleveland, Ohio, announces appointment of *John J. Wilber* as manager of the Cleveland district sales office.

CLARY CORP. has appointed *Kenneth F. Oldenburg* and *Milton Scozzafava* as assistant chief engineers, announces *Hugh L. Clary*, pres.

FEEDBACK CONTROLS, INC., announces appointment of *William M. Pease* as president.

INDUSTRIAL CONTROLS DIV., MANNING, MAXWELL & MOORE, INC., announces appointment of *Robert O. Wilson* as resident sales engineer, Philadelphia office; *John E. R. Johnson* as resident sales engineer, Chicago office; *Maurice R. Hyett* as resident sales engineer, Houston, Texas; and *Jack L. Gates* as resident sales engineer, Tulsa office.

ALLEN B. DuMONT LABORATORIES, INC., Clifton, N. J., has appointed *Thomas T. Goldsmith, Jr.* as vice president and general manager of the newly consolidated Government and Research Division, and *Irving G. Rosenberg* as vice president and general manager of the Technical Products Division, announces *David T. Schultz*, president.

T. Goldsmith, Jr.
A. B. DuMont

L. R. McIntosh
High Voltage Eng.

G. K. Turner
Spinco Div.

HIGH VOLTAGE ENGINEERING CORP., Cambridge, Mass., announces the appointment of *Lloyd R. McIntosh* as general manager.

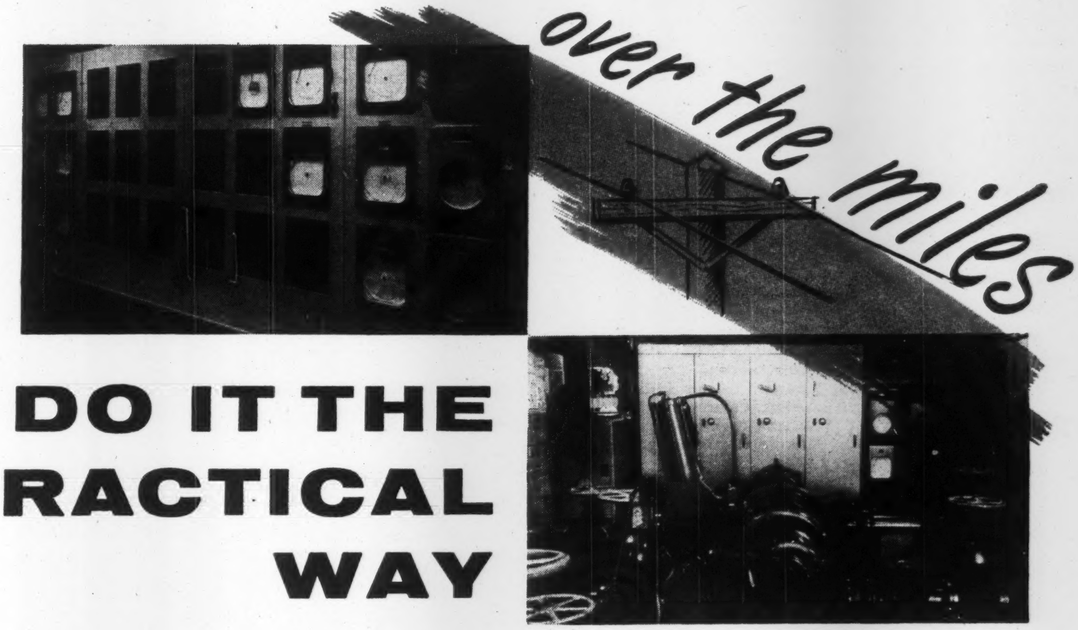
SPINCO DIV., BECKMAN INSTRUMENTS, INC. announces appointment of *George K. Turner* as Chief Electronics Engineer.

INFRA ELECTRONICS CORP., Roseland, New Jersey, announces the promotion of *Fenimore Fisher* to Chief Engineer of its Motor and Generator Division.

UNIVERSITY OF ROCHESTER has named *Dr. Thomas S. Keenan* administrator of the new University Computing Center.

NEW LONDON INSTRUMENT CO., New London, Conn., announces the appointment of *Samuel Gubin* to general manager, *Joseph C. Worth, Jr.* to sales manager, and *R. C. Reynolds* to purchasing agent.

to SEE and DO...



DO IT THE PRACTICAL WAY

with HAMMARLUND

Centralized Operations Control

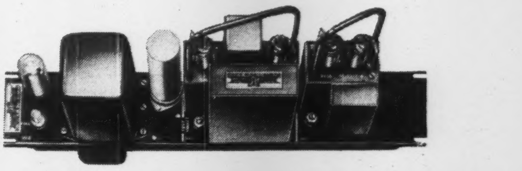
Hammarlund COC equipment provides the communications link between a central control station and all remote stations in a telemetering, supervisory control, or remote control system, or any combination of these systems. It is simple, reliable and extremely versatile. It is economical—in most cases it will pay for itself in less than two years.

COC equipment can provide communications over a standard telephone pair, or a radio or microwave channel — without modification. The equipment is capable of handling many functions over a single carrier.

Hammarlund equipment has proved itself in many fields as the really practical way to link long distance operation and control. Operation and maintenance of the system is so simple it can be accomplished with present personnel and at the same time relieves those personnel to perform more important work in maintaining high quality service.

Let Hammarlund help you solve your telemetering and control problems, without obsoleting your existing instruments. Send for complete information, or ask any specific questions... ask for Bulletin I-356.

COC equipment is made up of Dual Signalling Units, Single and Dual Transmitter Units, and Single and Dual Receiver Units mounted on standard 19″ panels. With this design, additional functions can be achieved with Hammarlund's add-a-panel packaging — without re-engineering the existing control system.



Established 1910

HAMMARLUND
MANUFACTURING COMPANY, INC., 460 West 34th Street, New York 1, N. Y.
INTERNATIONAL DIVISION: 13 East 40th Street, New York 16, N. Y.

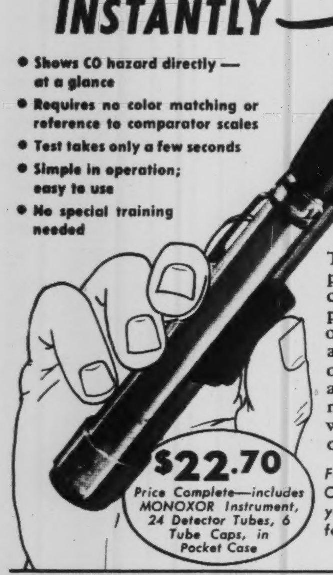
For more information circle **49** on inquiry card.

SHOWS
CO Hazard
INSTANTLY

- Shows CO hazard directly — at a glance
- Requires no color matching or reference to comparator scales
- Test takes only a few seconds
- Simple in operation; easy to use
- No special training needed

MONOXOR
CARBON
MONOXIDE
DETECTOR

REPLACEABLE DETECTOR TUBE CONTAINS YELLOW CHEMICAL WHICH TURNS BROWN WHEN AIR "SNIFFED" THROUGH DETECTOR TUBE BY PENCIL-SIZE ASPIRATOR CONTAINS CARBON MONOXIDE



$22.70
Price Complete—includes MONOXOR Instrument, 24 Detector Tubes, 6 Tube Caps, in Pocket Case

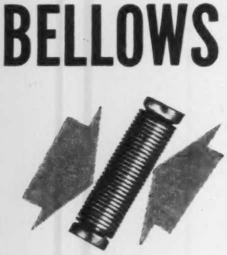
The MONOXOR detects presence of CO, even in concentrations as low as 50 parts CO per million parts of air. Particularly useful for a spot-check of carbon monoxide contamination in garages, vehicular tunnels, mines, industrial plants and wherever gas appliances are operated.

For Complete Particulars . . . Clip this ad and mail to us with your name and address, or write for Leaflet 859.

BACHARACH INDUSTRIAL INSTRUMENT CO.
7301 PENN AVENUE • PITTSBURGH 8, PA.
Telephone: MOntrose 1-0702 M-9

For more information circle 50 on inquiry card.

BRIDGEPORT BELLOWS
SAVE SPACE



For miniaturization and weight reduction in instruments, aircraft and similar applications, Bridgeport small diameter bellows offer many new design opportunities. Seamless metal bellows in 1/4" and 5/16" diameters are available exclusively from Bridgeport Thermostat in a wide range of characteristics and metals. Other sizes up to 5 7/8" O.D.

Mr. Controls
Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION
DEPT. (EE-125), MILFORD, CONNECTICUT
☐ Send data on small-diameter bellows
☐ Send Bellows Engineering Bulletin
NAME________
COMPANY________
ADDRESS________
CITY________ STATE________

For more information circle 51 on inquiry card.

PEOPLE—CONTINUED

SIMPSON ELECTRIC COMPANY'S founder *Ray R. Simpson* was honored recently by a testimonial dinner in Chicago commemorating his 50th year in the electrical instrument business.

Ray R. Simpson
Simpson Elec.

Ed. F. Crafts
Brush Electronics

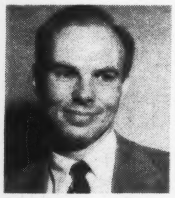
W. E. Chope
Indus. Nucleonics

BRUSH ELECTRONICS CO., DIV. OF CLEVITE CORP., announces appointment of *Edward F. Crafts* as Advertising and Sales Promotion Manager.

INDUSTRIAL NUCLEONICS CORP. president, *Wilbert E. Chope*, has been selected as the "Outstanding Young Electrical Engineer of 1955" by Eta Kappa Nu, electrical engineering honorary fraternity.

COMPUTER CONTROL CO., INC., Wellesley, Mass., announces election of new officers: *Robert W. Brooks*, president; *Franklin R. Dean*, vice-president of East Coast operations and chief engineer; *Kenneth M. Rehler*, vice-president of West Coast operations; *Robert L. Massard*, Treasurer; and *William P. Horton*, clerk.

R. W. Brooks
Computer Control



R. A. Gardiner
Thompson

I. L. Kasindorf
Servomechnisms

ELECTRONICS DIV., THOMPSON PRODUCTS, INC., Cleveland, Ohio has appointed *Robert A. Gardiner* as Automatic Controls Consultant to head research and development work of the division, announces *William M. Jones*, Div. Mgr.

SERVOMECHANISMS, INC. announces the appointment of *Ira L. Kasindorf* as Chief Development Engineer, Eastern Components Division, Westbury, New York.

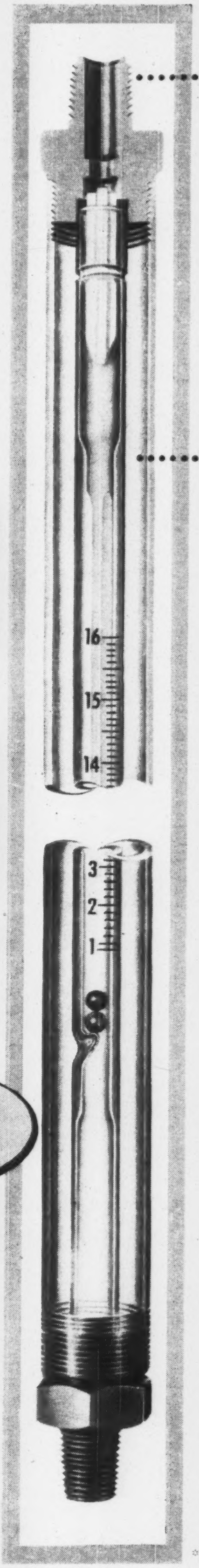
LANDSVERK ELECTROMETER CO., Glendale, Calif., announces the appointment of *W. R. Hanson* to supervise production of Type IM-93 dosimeters for the U. S. Signal Corps.

SEQUOIA PROCESS CORP., Redwood City, Calif., announces appointment of *Beardsley Graham* as assistant to *Paul Cook*, president.

CONTROL SPECIALISTS, INC., Inglewood, Calif., consulting engineers in automatic control systems, announce newly elected officers: *D. T. McRuer*, Chairman of the Board; *A. P. Henry*, President; *I. L. Ashkenas*, Vice-President and Chief Engineer; *E. T. Sprague*, Secretary and Business Manager; and *G. E. Click*, Treasurer.

VINCENT A. SCHNEIDER, Union, N. J., announces that *David Rufus* is now with his organization as a sales representative.

guarded predictability flowmeter



permits direct connection to pipe!

protects fragile glass tube!

Complete unit consisting of predictability flowmeter with plastic tube, s.s. pipe ends and gaskets.				Guard only for ready attachment to flowmeter consisting of plastic tube, s.s. pipe ends and gaskets.	
Max. Flow in ml./min.		Cat. No.	Price	Cat. No.	Price
Air	Water				
83.8	1.35	G9142T	28.00	G9142L	9.50
426	10.30	G9143T	28.00	G9143L	9.50
2120	59.5	G9144T	30.50	G9144L	12.00
18400	545	G9145T	38.00	G9145L	19.50
68200	2070	G9148T	39.50	G9148L	19.75

s.s. hose ends available for connection to rubber tubing

G 5076 H 1/8" hose end for sizes **G9142** and **G9143**........ea. **1.65**

G 5081 R 1/4" hose end for sizes **G4144, G9145** and **G9148**........ea. **1.50**

Now . . . new **Guarded Predictability Flowmeters** developed by **Manostat Corporation** fill the need of research and industrial laboratories for *rugged, precise* flowmeters at exceptionally low cost. They are the answer to numerous requests by users of our predictability flowmeters for a truly versatile instrument. Among its features is its strong Tenite II* outer plastic protecting tube not in contact with fluid. Materials which do contact fluid are corrosion resistant stainless steel and Hycar** rubber.

For further information on the predictability flowmeters themselves write for bulletin.

*Tennessee Eastman **B. F. Goodrich Chem. Co.

The EMIL GREINER Co.

20-26 N. MOORE STREET DEPT. 230, N. Y. 13, N. Y.

For more information circle **52** on inquiry card.

Your prospects and the world's largest computer

- As an engineer at IBM, your prospects are virtually unlimited. You work with the world's *largest* computer! And this long-range project offers you the chance to achieve greater satisfaction and growth.

This operation, of front rank importance, and growing by leaps and bounds, requires outstanding men to receive advanced computer training at IBM's Kingston, N.Y. school . . . to undertake responsible assignments in locations throughout the Eastern U.S. Employing the latest computing and calculating techniques and testing equipment, you'll gain experience unequalled anywhere in electronics. And every channel of advancement in this accelerating project will be open to you. The future looks good at IBM, long an outstanding leader in its field.

If you have an E.E. degree or equivalent experience, write now to: N. O. Heyer, Room 3603
International Business Machines Corp., Kingston, New York

IBM
INTERNATIONAL
BUSINESS MACHINES
CORPORATION

DATA PROCESSING • ELECTRIC TYPEWRITERS •
TIME EQUIPMENT • MILITARY PRODUCTS

INSTRUMENTS and AUTOMATION

Biographies of significance

SIGNIFICANCE

IN past issues of *I&A* we have tried to portray the growth and status of instrumentation within various fields in terms of outstanding men within those fields. This month we want you to meet George Forster, Jr., Gas System Foreman, The Texas Company, and Axel Peterson, Head of the Department of Instrumentation, Mellon Institute of Industrial Research. Their "biographies of significance" illustrate two basic fields of instrumentation—research, and oil and gas distribution.

In the oil and gas industry the California Natural Gas Association (CNGA) and the Southern California Meter Association (SCMA) are two of the leading professional societies: George Forster has been (and still is) a leading figure in both.

A clue to his contributions is to be found in the fact that he was not only the 14th President of the SCMA, but also has served as Secretary-Treasurer of the SCMA for 11 years, an office he still holds. As all who participate in society activities know, the key position in any society is not that of the President, it is that of Secretary-Treasurer.

George failed to mention his part in the development of the natural-gas psychrometer and its procedure (used for measuring the water vapor content of natural gas flowing through a pipeline; now a part of the CNGA Charcoal Test Bulletin and in use by all companies). George has presented several talks on coefficient calculation, specific gravity measurement, charcoal testing and gas measurement, etc., before the CNGA, SCMA, API and the Long Beach school adult education group.

We are pleased to acknowledge George's tremendous contributions, not only to his societies but to the entire field of process instrumentation. His biography emphasizes the importance of society affiliation, and shows the type of instrumentation of significance in the oil and gas industry.

* * *

We have often pointed out that the modern research organization requires three basic essentials—instruments, researchers, and an instrument man to match the instruments to the researchers. Axel Peterson is an outstanding example of this third key classification of men so important to modern instrumentation (as are Charles Lucks of Battelle and Clarence Glassbrook of Stanford—whom you have already met in these columns). "Pete," as he is known to his many friends, took charge of the Department of Instrumentation at the Mellon Institute of Industrial Research when it was first created in 1951. Thus its entire growth has been under his direction, including its testing services, training and advisory services, and instrument development and research services. The biographical data which follow outline a complete and efficient instrument consulting service and supply center for a research organization.

Readers of *I&A* know Dr. Peterson in connection with the disclosure of the exciting Peterson microbalance—reported in the July, 1955 issue of *I&A*. We are pleased this month to acknowledge his key services in the field of research-type instrumentation, and his many contributions to the field of Instrumentation in general.

GEORGE H. FORSTER, JR.

George Forster, Jr., was born in Colorado, September 16, 1902. His family moved to California in 1912, and he graduated from high school in South Pasadena. He has supplemented his technical education by night school courses and an I.C.S. course in mathematics.

His instrument work began in 1921 with the Union Oil Company of California, in the laboratory of the Oleum Refinery, where his duties included test and inspection of petroleum products, fuel oils, and asphalt.

In 1923, George took charge of the laboratory of the Crump-Steele Company, which had a small topping plant on Signal Hill. When this company was bought by the Dollar Steamship Company, it became known as the Olympic Refining Company.

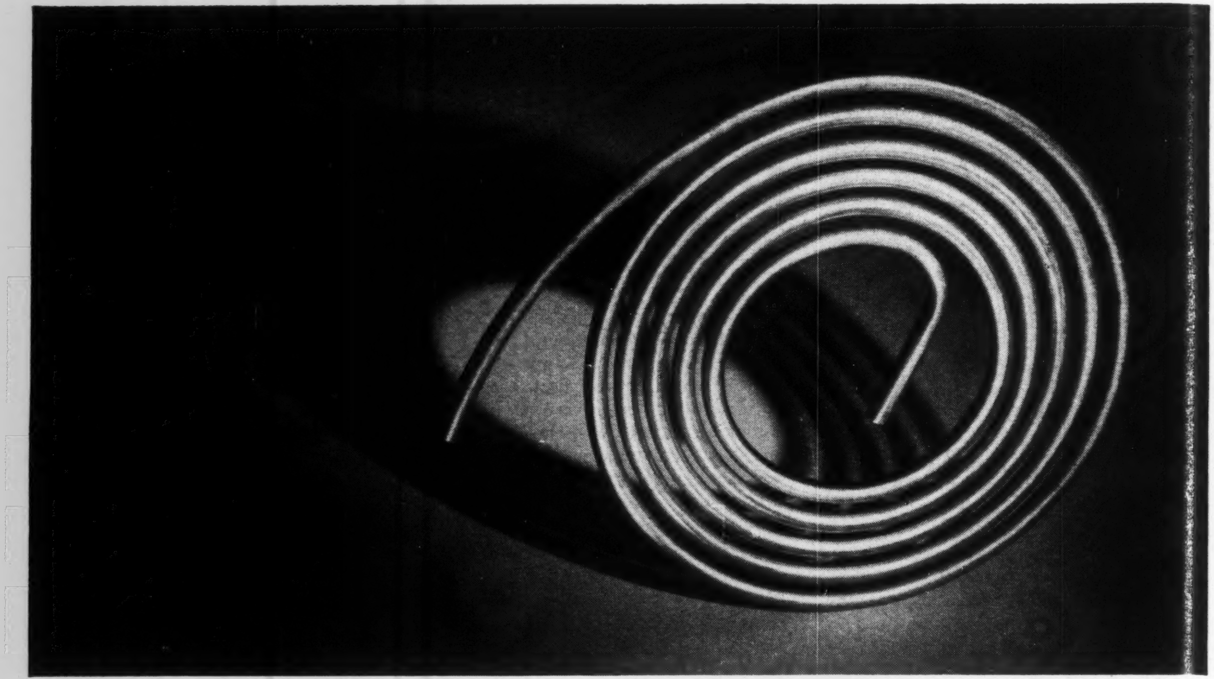
In 1925, George joined the California Petroleum Corporation in their main natural gasoline absorption plant on Signal Hill. His position involved plant laboratory work plus computing of coefficients for orifice flowmetering; thus began his work in the testing and measuring of natural gas, his major field of instrumentation for 30 years.

He rapidly advanced from plant work to field work to Head Field Tester, including duties of supervision of field testers, royalty gasoline settlements, tests necessary for orifice-meter-coefficient corrections, calculations of coefficients, chart computations, balancing of system gas figures, etc. His job was not affected when The Texas Company bought the California Petroleum Corporation in 1928.

He married Theresa C. Ragan, an employee of the California Gasoline Company, on June 17, 1927.

His affiliation with the California Natural Gasoline Association began in 1928, and in the following years he served on several of their committees: (1) Specific Gravity of Natural Gas; (2) Charcoal Testing of Natural Gas; (3) Gas Measurement.

In 1933, he joined the Southern California Meter Association, and after serving on several of their committees, was elected to serve as their 14th president, 1939-1940. Due to the



Superior offers the widest range of sizes and alloys in top quality instrument tubing

Superior Tube Company produces the finest instrument tubing in a wide range of sizes and alloys—offers you as standard products what many makers would classify as specialty tubing.

1. NEEDLE TUBING

The stainless steel links in this recording instrument are made of Superior needle tubing. The high strength, stiffness, and strict dimensional tolerances characterizing this tubing—originally designed for surgical uses—have opened new fields of industrial applications when used as mechanical tubing.

2. PRESSURE AND SUPER PRESSURE TUBING

A spiral windpipe made of Superior 304 cold-drawn seamless stainless steel tubing. Pressure tubes are used to convey fluids at elevated temperatures and pressures. Produced in stainless, carbon and alloy steels in sizes to withstand pressures up to 100,000 psi.

3. BOURDON TUBING

A "C" tube element for a pressure gage. The shaped Bourdon tube serves as the actuating element for the majority of pressure indicating and recording instruments. Helix and spiral elements are also fabricated from the wide range of alloys available at Superior—a range that makes it possible to satisfy any set of conditions in the use of Bourdon tubing.

4. CAPILLARY TUBING

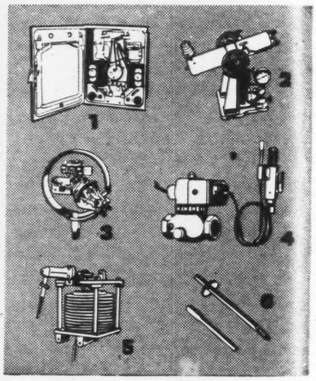
A thermostatic instrument pressure transmission element with a coiled unit made of Superior Type 321, capillary tubing. Superior capillary tubing is used primarily for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Capillary purposes, in general, require a heavy-wall tube with an ID of .006" to .030". Types 347, 321, 316, MONEL* and carbon steels are recommended analyses.

5. LARGE OD LIGHT WALL TUBING

A large OD light wall tubing bellows in a pressure actuating element. Present applications for large OD light wall tubing include bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, and casings for radioactive well logging instruments. Sizes offered up to 2½" OD.

6. MECHANICAL TUBING—INSTRUMENT LINE

Various fabricated parts—all made of Superior mechanical tubing. Superior mechanical tubing can be either seamless or WELDRAWN† grade used statically or dynamically, but not subjected to severe temperature or pressure. It is produced in sizes up to ⅝" OD within production limits, in many special shapes, and in over 63 standard analyses and mechanical properties.



Send for free copy of Bulletin 40—A Guide to the Selection and Application of Superior Tubing. Write Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ⅝" OD—certain analyses in light walls up to 2½" OD

On the West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif.

*Reg. T.M. International Nickel Co.
†Reg. T.M. Superior Tube Co.

For more information circle 53 on inquiry card.

resignation of the Secretary of SCMA in 1944, he was appointed to fill out the term and has been reelected to serve as their Secretary-Treasurer for now 11 years, which office he still holds. (This is only a spare time job from his regular employment with The Texas Company.)

He was advanced by The Texas Company in 1948 to Assistant Gas System Foreman in the Los Angeles Basin Area. This occupation covered assistant supervision of the installation and maintenance of the wet-gas gathering and dry-gas distribution pipeline systems, orifice meter runs, orifice meters, royalty testing, etc. He continued on the CNGA committee for Charcoal Testing of Natural Gas.

In 1952, he was promoted and transferred to the Texas Company's Ventura District as Gas System Foreman, having full charge of the Wet and Dry gas field pipeline systems, royalty testing, gas system balancing, field and gasoline plant gas measurement, and consultant for the chart reading and coefficient department.

George says "I have been reading *Instrument and Automation* as a subscriber since about 1948. Your fine magazine has proved very beneficial to the entire membership of the SCMA, not only through the publication of the Association's papers, but also because of the many interesting articles and features published therein."

For hobbies, he enjoys amateur photography and raising flowers.

AXEL H. PETERSON

What do research laboratories need most in the realm of instrumentation? When asked this question by your editor, Dr. Axel H. Peterson, of world-famous Mellon Institute, was stopped cold. He could think of plenty of needs but he couldn't establish a priority list on the spur of the moment. His first strong reaction was that the research scientist needs to spend more money on instruments that are already developed. As an example he cited the modern electrical recorder . . . more of this in a moment.

Dr. Peterson got off to an early start in science. When he was in the eighth grade of school in the early thirties, he sold papers, saved his money, bought an old analytical balance, and therein lies a story whose climax may be near. Part of this story was told in *I&A*, July, 1955, and in the *Pittsburgh Press*, Sunday, July 31, 1955, which reported his spectacular improvements on analytical balances, increasing an already sensitive instrument by an additional 10,000, and making it automatically recording at the same time. But in between these developments, a few other things happened—including a B.S. in Chemistry (1939) from the University of Florida, an M.S. (1947) from Northwestern University, and a Ph.D. (1949) from Indiana University. His thesis "Electronic Measurements of Aerosols and Gases by Means of Scattered Light" was, significantly, in the field he has chosen as his specialty—instrumentation.

Pete joined the Mellon Institute of Industrial Research in 1949 on a fellowship concerned with instrumentation for the synthetic rubber industry.

The Department of Instrumentation was created at Mellon in 1951—and Pete took over from the beginning. Its growth and important developments are revealed dramatically in the following outline of his Department and its activities.

Department of Instrumentation

The year 1955, like previous years, has been a period of rapidly increasing use of new instruments by the Fellowships at Mellon Institute. The Instrument Department has catalyzed this by many new instrument developments, purchases, and services. As Instrumentation Departments are still relatively new to research organizations, this report will illustrate the wide range of research services provided by such a Department at Mellon Institute.

Instrument Rental Service

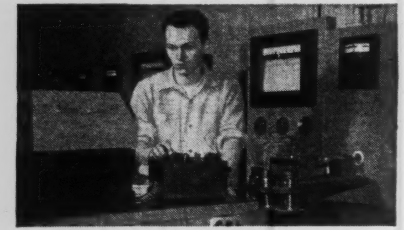
The Instrumentation Stockroom has several thousand instruments which are available to the Fellowships on a rental basis. Some examples of these are microscopes, analytical balances, refractometers, pH meters, amplifiers, and recording potentiometers. Fellowships are encouraged to purchase instruments which they will need for an extended time—the primary function of the rental service is to serve the *short-term needs* for instruments. Another related service provided is the maintenance of an inventory list of instru-

Lab Testing Certifies Accuracy of Brown Thermocouples

IT TAKES an accurate thermocouple . . . as well as an accurate instrument . . . to make precise temperature measurements. Actually, the overall precision to which you can measure *cannot* be closer than the thermocouple calibration.

The precision you get in Brown thermocouples results from constant control and testing. Materials must meet rigid specifications. Alloys are melted to exact composition, and accurate control is exercised over every production operation.

Every lot of wire used in Brown thermocouples goes through its paces in the Brown wire-checking laboratory. Each wire spool is calibrated against standard thermocouples that have been certified by the National Bureau of Standards. Specially designed test furnaces and high precision measuring apparatus are used to check at several points throughout the temperature range within which the wire will be used. Calibration must fall within close tolerances before any spool is accepted. Actual test calibration figures are tagged on the spool.



Technician in the Brown wire testing laboratory checks thermocouple calibration.

Special calibration data can be furnished when required. For your own calibrating purposes, you can get extra calibration points at spots where you desire even greater precision.

This *extra* care in calibrating thermocouples pays *you* dividends. For it assures that you always get identical precision with every Brown couple you install. It assures, too, that the Brown instruments connected to the couples will be giving you the full accuracy of which they're capable.

FURNACE CONTROL

Here's why it pays to know your HSM

HSM
HONEYWELL SUPPLIES MAN

DICK BULL, HSM (Honeywell Supplies Man) in the Los Angeles area, helps a maintenance supervisor at Harvey Aluminum, Division of Harvey Machine Co., Inc., Torrance, Calif., to choose special thermocouple wire for a calibration job on an industrial furnace.

Individual consultation on pyrometer supplies problems, by men who specialize in this field, is the foundation of the HSM Plan. It's the convenient, economical way to place all your buying of pyrometer supplies on a systematic basis.

Hundreds of plants are now using the HSM Plan. For a discussion of how it can work for *you*, call your nearby HSM at your local Honeywell office . . . as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—In Canada, Toronto 17, Ontario.

● **REFERENCE DATA: Write for Pyrometer Supplies Buyers' Guide No. 100-6.**

H HONEYWELL

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

For more information circle **54** on inquiry card.

ments which are owned by Fellowships.

Testing Service

A large and growing number of Fellowships request the Instrument Department to perform a complete test for them. Generally this applies to a test which involves a large, complex, and expensive instrument—or perhaps a half dozen smaller instruments which in the aggregate are large and expensive. In the past year the Instrument Department has considerably improved its potential for this work by the acquisition of both personnel and instruments.

Processing Equipment

The Instrument Department has a large number of furnaces, crushers, mills, rollers, ovens, presses, dryers, and related equipment. This equipment is too large to be transported to labs so it is used where it is located. This equipment is rented from the Instrument Department. Material is frequently processed by the Instrument Department in this equipment for the Fellowships.

Training in Instrument Operation

Even though an instrument is complex, it is often desirable for Fellowship personnel to learn its operation. The Instrument Department provides the training when so requested. Generally, training is done using samples or work of direct interest to the Fellowship. Although some scientists spend considerable time in witnessing a test made by the Department, they may not have time or inclination to learn to operate the instrument. Therefore, the Department is flexible in its mode of operation—it will provide the instrument, or the instrument and operator, or any combination in between, at the option of the Fellowship.

Advisory Service

The advice of different Instrument Department members is frequently sought concerning the conduct of experiments and the use of instruments. This service has increased considerably, reflecting the rapid developments in the instrumentation field.

Instrument Engineering

The advisory service is frequently used in connection with measurements new to the scientist. Sometimes he is not aware of commercial instruments to perform his job; in many cases there are none. However, instruments often can be adapted or combined from the stockroom to do the job. In other cases an instrument may be developed for this function.

An example of this is gaseous phase chromatography, for which the Department has engineered several types of circuits. Another example is the engineering of special pressure transducers for the Multiple Petroleum Fellowship. The instruments so developed have been in continuous demand by other Fellowships.

Instrument Construction and Maintenance

There is a continuing demand for the Department to construct instruments previously developed here or elsewhere. Facilities for this work have been expanded considerably. The Department seldom constructs an instrument which can be obtained commercially unless it is felt that improved performance is essential and can be obtained only by development. The price for commercial instruments frequently seems high but, generally, a *little consideration shows that the cost of construction is a good deal higher than outright purchase if all factors are considered.*

The facilities for construction also serve for maintenance work. A wide variety of instruments were repaired last year for the Fellowships, in addition to the instruments of the Instrument Department.

Instrument Research

The recording microbalance (recently disclosed in *I&A*) has attracted much attention. The Instrument Department is making a basic study of the balance and weighing techniques.

Considerable success has resulted from the study of the balance. A major improvement is the development of a procedure to adjust the balance to be insensitive to the tilt of the building and balance table; a factor of improvement of several hundred has been obtained. The procedure consists of adjusting the center of gravity of the balance until the balance itself provides no mechanical restoring force; electrical restoring force is then provided in such a way as to be insensitive to tilt. For all practical purpose the important factor of tilt has been eliminated. Also, floor vibration effects have been reduced—the balance can now be mounted only on rubber shock mounts.

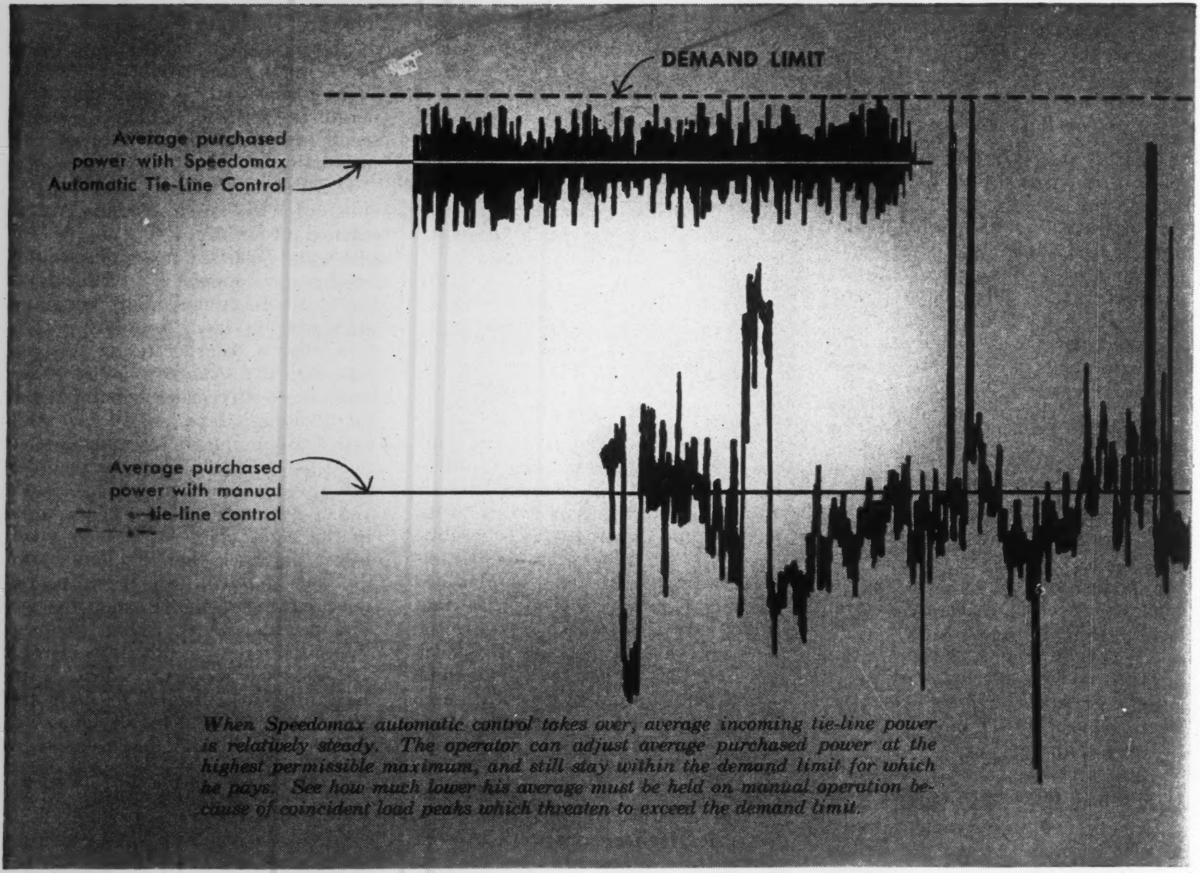
Ambient temperature effects on weighing remain a major obstacle. Recently a simple method of introducing heat to a balance was tried and a major improvement in overcoming sensitivity to ambient temperatures resulted. Other developments on weighing techniques are proceeding.

Dr. Peterson admits that the results of this microbalance work startled even him. (It also pleased him—and justified the emphasis put on this development by *I&A.*) Having spent uncounted hours weighing manually, his favorite hobby now is to admire a recorder doing this job automatically. Another hobby is his small boy—a recorder is doing a job there also—a tape recorder in this case. (He points out similarities in these two hobbies. The tape recorder gets every inflection of his boy's voice, gets every pause, every word in the right place—it does a much better playback than his father can do. The same with the recording potentiometer and the balance; the record reveals things about balances that observers were unable to detect.) Dr. Peterson feels that scientists are beginning to catch on to these tremendous improvements in the way of doing research and that a great instrumentation boom is going to occur in laboratories.

Probably the most astonishing event in Dr. Peterson's life was when he joined the Navy and was assigned to electronic instrumentation duty—in the then revolutionary field of radar electronics. In a short time he was put in charge of a complex radar system for a carrier that may have contained more electron tubes than were contained in all the pH meters and spectrometers and all other devices in all chemical laboratories in the world at that time.

At present, he is President of the Pittsburgh Section, Instrument Society of America, and is also Vice Chairman of the Gordon Research Conference on Instrumentation. He has served several years as Chairman of the Analysis Instrumentation Committee of the ISA and was responsible for organizing the ISA Analytical Instrument Clinics with the help of Mr. Richard Rimbach.

Pete tells us that he reads every issue of *I&A*, and has been doing so for 15 years. He says "*I&A* does a superb job in reporting available commercial instruments. The large total of instruments reported in both the advertisements and editorial matter is essential to my job of keeping informed about the quickest way to do a job—which is to buy the best instrument for that job."

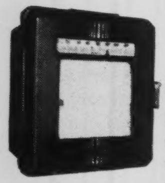


When Speedomax automatic control takes over, average incoming tie-line power is relatively steady. The operator can adjust average purchased power at the highest permissible maximum, and still stay within the demand limit for which he pays. See how much lower his average must be held on manual operation because of coincident load peaks which threaten to exceed the demand limit.

Industrial Power Plant Engineers:

Look at the cost-saving difference

between Speedomax® automatic control and manual control



Operating and management people in industries making a diversity of products . . . machinery, paper, petroleum, textiles, chemicals . . . find that Speedomax automatic control cuts costs month after month. Here's why:

Speedomax electronic stability and mechanical stamina, relied on by a majority of utilities for their station control rooms and dispatcher's offices, assure fast—and lastingly precise—control action.

In industrial plants operating interconnected with a neighboring utility, this control action is provided by Speedomax Tie-Line Controllers to obtain economical purchased power, as shown above.

In plants operating isolated, this same control action enables Speedomax Frequency Controllers to hold frequency at an average of 60 cycles. In most cases, 24-hour time error is comparable to that obtained by the power companies themselves.

Write for the facts to Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa. Better yet, talk with an experienced L&N Sales Engineer in any of 18 District Offices.

LEEDS NORTHRUP
instruments *automatic controls • furnaces*

For more information circle **55** on inquiry card.

Do You Really Know Your Instruments?

YOU use many different types of instruments—perhaps pneumatic, perhaps electronic, perhaps all types. (This statement probably applies to 99.9% of all readers of *Instruments and Automation.*) Thus the question "Do you know your instruments?" is more than an academic one; it is one that asks how effective you are as an "instrument man," how useful you are to your organization as an instrumentician. This question merits your deepest personal consideration.

The question does not refer merely to your maintenance functions of a routine nature. If it did, the question would not be important—and indeed the answer from most of you could be an immediate "yes." But you do not have to "know" an instrument to service it. Consider the deeper and much more important implications of this question as applied to any one of your instruments:

First—in how many different ways can you use the instrument, including unusual and unorthodox variations?

Second—how can different parts of the instrument be adapted to other uses?

Third—how can the ranges be altered?

Fourth—what are the limiting factors that may not normally be given as manufacturer's data—drift, inaccuracies, maximum input signal, etc.

Fifth—what variations in input and output would adapt the instrument to other instruments—including other recorders or amplifiers or controllers?

Let us see how important these questions are by using, as an example, an instrument that you may think you know well—a conventional recording potentiometer. The potentiometer may have a chopper-type input, an amplifier, a servomotor.

Let us consider the chopper first. Can you use it backwards to convert an a-c signal to a d-c signal? If so, how? What will be the noise levels? What signal amplitudes can be accommodated? What type of input and output networks are required for range changing?

Now let us consider the amplifier. What type of signal can be fed directly to the amplifier? What matching networks are required? What is the sensitivity? The noise level? The drift? The input impedance? The amplitude and impedance of the output signal from the last stage?

Now for the servomechanism that drives the recording arm. What is the frequency response? The power output? How can a takeoff be made to an outside element? What are the input requirements to the drive motor?

Do you still think that you "know" your recording potentiometer?

Almost every instrument problem represents an adaption of an existing instrument to an application that requires unorthodoxy of some degree. In order to make this unorthodox adaption, it is essential to have knowledge of the inherent capabilities and limitations of the entire instrument, including its individual elements. With this knowledge, limitless applications will suggest themselves to you; many problems will be solved rapidly and economically by you; the depth of your own imagination and creativity will surprise yourself. A pH meter will become a useful low-level d-c amplifier in your eyes; a radio will become a radio-frequency voltmeter; a pressure regulator will become a force-balancing mechanism; every one of your instruments will become a powerful device for many applications within your own organization.

Take a closer look at each of your many instruments—and ask yourself "Do I really know that instrument?"

Milton Aronson

What *Type Flowmeter* is *Right* for You?

COX
TYPE 8
TYPE 10
TYPE 12
TYPE 14

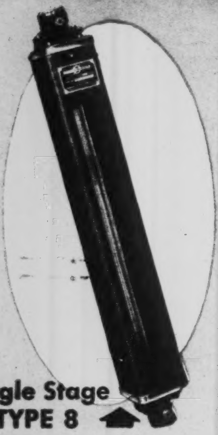
FLOWMETERS

All have *"Inner Wall Guide"* Design for Perfect Match of Tube and Float

If, like many of our customers, you depend upon flowmeters primarily for production, the Single Stage **Cox Type 8** provides the right combination of accuracy, readability, and quick response so essential for low cost performance of this type. Lightweight, dependable, and easily operated, the variable area Type 8 is ideal for a wide range of production processes.

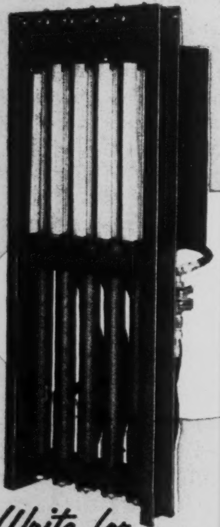
Should you require a research-type flowmeter capable of indicating very low flows in engines, pumps, carburetors, etc., the Multiple Stage **Type 10** is the answer. Used extensively in automotive engine laboratories, it is accurate within ± 1% of the reading at any point on the scale.

Where high capacity, high accuracy is essential, Cox Multiple Stage **Type 12 Flowmeters** — 40, 90, and 100 Series — and the high pressure **Type 14** are unsurpassed. Logarithmic scales provide the same degree of readability (from ¼% to 1% depending upon the Series) at *all* points throughout the flow range. Capacities up to 130000 PPH are available, where needed. And like all Cox Flowmeters, the Type 12 and Type 14 feature "Inner Wall" guides, integral with the tapered tube, which accurately match contours of the float, and assure stability and repeatability of float position. Explosion-Proof backlighting with translucent scales for maximum visibility available on the Type 12 and Type 14.



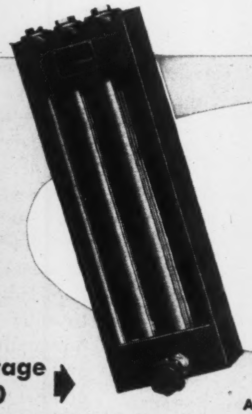
Single Stage
TYPE 8

Ideal for measuring rate of flow in production line processes where accuracy and performance must be matched by low cost operation.



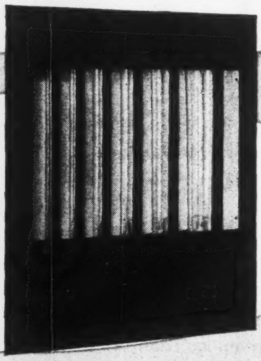
Multiple Stage
TYPE 14

A high pressure Multiple Stage flowmeter for pressures up to 1000 p.s.i. Uses the same logarithmic scales as the Type 12 and provides unsurpassed readability. Capacities to 36000 PPH.



Multiple Stage
TYPE 10

Combination laboratory-industrial flowmeter. Developed to handle low flow rates and varying temperatures and viscosity encountered in engine, carburetor and pump testing.



40
Series

Multiple Stage—TYPE 12

Available with bypass orifice which greatly raises maximum range (up to 90000 PPH) without increasing number of tubes. Like all Cox Flowmeters, the Type 12 is calibrated on Cox Calibrating Stands—accepted primary standard of calibration throughout the automotive and aircraft industries.

Write for
FREE LITERATURE

Commercial Research Laboratories, Inc.

20 BARTLETT AVENUE • DETROIT 3, MICHIGAN

MAKERS OF COX INSTRUMENTS SINCE 1912: CARBURETOR FLOW STANDS · ENGINE INDICATORS · FLOWMETER CALIBRATING STANDS · FUEL NOZZLE TEST STANDS · MAGNETIC THICKNESS GAGES · VIBRATION RECORDING EQUIPMENT · BALANCED ELECTRONIC EQUIPMENT FOR PRESSURE AND VIBRATIONS

For more information circle **56** on inquiry card.

National Simulation Conference

JOHN H. McLEOD, JR., IACC

THE NATIONAL SIMULATION CONFERENCE—More than a collection of technical papers, this conference revealed some trends which are destined to exert a powerful influence on the instrumentation and automation of industrial processes and machines, from this time now and on!

READERS will note that I am wearing a different hat to write this report. That's because I believe this excellent conference will receive adequate coverage elsewhere for those who are interested in simulation per se. The IACC stands for the Industrial Analysis and Control Council, which a group of us in the Los Angeles area organized a couple of years ago to try to do for computers and process control what the Simulation Councils have done for computers and simulation. After a few meetings, however, it became evident that not enough people knew enough (or were willing to talk enough) about the subject to make the discussions rewarding. For that reason I would like to consider the National Simulation Conference from the point of view of one who is interested, as I am, in the application of electronic computer and simulation techniques and equipment to the analysis and control of industrial processes.

The First National Simulation Conference was held on January 19-21, at Dallas, Texas.

The Conference was sponsored by the Dallas-Fort Worth Chapter, IRE, Professional Group on Electronic Computers; the Dallas-Fort Worth Section, IRE; the North Texas Section, AIEE; and the Dallas-Fort Worth Chapter, Association for Computing Machinery; and was devoted to simulation and related computing techniques—a relatively narrow field. It is therefore interesting to note that more than 400 people attended the sessions, which were planned for less than two-thirds that number. The significance lies in the fact that many who attended were not interested in simulation as such, but in the application of the techniques and equipment discussed to their own varied problems.

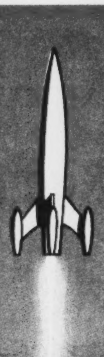
Let me give you some "ferinstances": The possibility of using the techniques described by *David Otis* (in his paper "Electric Analogy to Transient Heat Conduction in a Medium with Variable Thermal Properties") and by *P. J. Hermann* (speaking on the use of an analog computer to study transients in a laminated boundary) for the analysis of heat-flow problems is obvious. And *Elmore Blanton* (in his paper "Performance Requirements for Flight Tables") and a subsequent paper ("The Design of a High-Performance Hydraulic Servo") by *M. S. Feder* and *K. V. Bailey* described work which would be of interest to anyone faced with the problem of designing a high-performance servo positioning system. *Ted Levine*, in a paper he prepared with William Blitzstein entitled "Optical Simulation of Radar," described an ingenious method of determining the position of an object by use of a revolving mirror to give a radar-type presentation. "The Derivation of Simulators of Gas Turbine and Other Physical Systems from Experimental Data" by *L. Wolin* should answer those who wail that "We can't simulate that process; we can't write the equations that describe its operation"; and "The Uses of Post-Flight Simulation

Historic Picture

Representatives of the four regional Simulation Councils meet for the first time at the Simulation Councils' joint "reception" which was held in connection with the National Simulation Conference in Dallas, January 19, 1956.

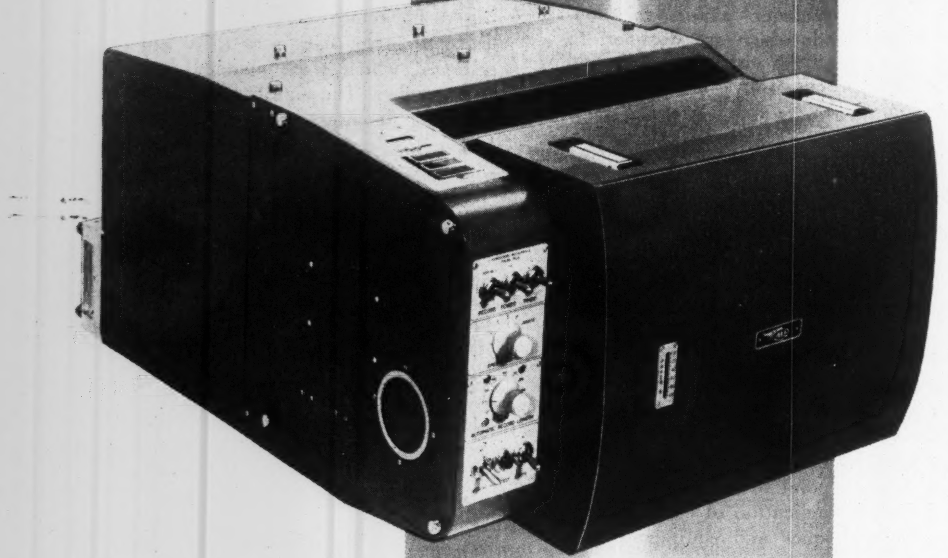
Shown from left to right are Normal L. Irvine, Aerojet General Corp., Western Past Chairman S/C; W. Frank Richmond, Jr., Glenn L. Martin Co., Ch. Eastern S/C; Richard R. Weber, Cincinnati Milling Machine Co., Retiring Ch. Midwestern S/C; and W. K. McGregor, Aro, Inc., Ch. Southeastern S/C.

the NEW



MIDWESTERN MODEL 591
RECORDING OSCILLOGRAPH

for laboratory or flight test recording



A few of its many features are—

12 inch width records • Recording speeds from .082 to 129.9 inches per second • Plug-in power supply units for immediate adaptation to 28 volts dc or 115 volts 60 or 400 cps power sources • Plug-in timing units which provide timing lines of .001 and/or .01, .01 and/or .10, or .10 and/or 1.0 second intervals • Precise timing synchronization between two or more units • Complete remote control facilities • Ability to operate under extreme temperatures and accelerations.

WRITE FOR COMPLETE DETAILS.

products

- Oscillographs (LABORATORY AND FLIGHT TEST)
- Magnetic Structures
- Galvanometers
- Amplifiers
- Bridge Balance Units
- Hydraulic Servovalves
- Torque Motors
- Servoamplifiers
- Data Repeaters

MIDWESTERN MI INSTRUMENTS

MIDWESTERN INSTRUMENTS

41st and Sheridan Road
Tulsa, Oklahoma

For more information circle **57** on inquiry card.

EDITORIAL—CONTINUED

Lou Wadel registers blissful relief on the last day of the National Simulation Conference as it becomes obvious that his many months of hard work have helped make it an eminent success. Lou's wife Carol, who also put in long hours, is wearing the corsage of camellias which was presented to her by John McLeod in behalf of all the Simulation Councils in appreciation of her contribution to the success of the Conference.

McLeod loses his place in his notes!

in Missile Flight Analysis" by *R. G. Davis* should suggest ways of using recorder charts to analyze processes. *Norm Irvine's* talk on "Simulation of Dead Time" is directly applicable to the determination of the effect of transport lag on process controllability, and *John Stroud's* "A Simulation System for the Study of Human Dynamics" gives some interesting insight into the difference which might be expected between predictable computer and unpredictable human control in closed-loop systems. *Vern Larrowe* and *Margaret Spencer's* "Use of Semi-Conducting Surfaces in Analog Function Generation" might suggest an approach to the problem of determining the optimum value of one variable as a function of two other variables when the empirical relationships are known but cannot be conveniently expressed mathematically, and finally the paper "A Comparison of Diode Switching Methods for Analog Function Generation" (which *Otis Updike* prepared and I presented) indicates ways in which these simple and inexpensive gadgets can be used to modify the response of electrical recorders and/or controllers in a predetermined way such that vapor-tension thermometer and flowmeter scales can be made linear, and nonlinear valve characteristics can be compensated.

Now see why I wore a different hat? This simulation business was started with Government money and has been largely dominated by the aircraft and guided-missile industry because the need was so urgent and the time so short that quicker and better methods were an absolute necessity for survival. Now, however, the techniques and equipment are available to all, and those who do not take advantage of these powerful new tools may well go down in their battle for economic survival.

Dear D. R.*:

At last month's meeting of our local ISA chapter, Walt Langerman of Fisher Scientific Company asked us why we were so excited about analog computers. The same question might be in your mind, so this month we put this personal letter to you right under John McLeod's comments on the National Simulation Conference, wherein he emphasizes the close relation between analog simulation and industrial instrumentation. Then we suggest that you go to the lead-off article this month: "Basic Applications of Analog Computers."

This still won't answer the question completely—for the simple reason that a huge, unexplored area of instrumentation is involved, and unexplored areas are difficult to describe accurately in detail. But the potential that lies behind this technique motivated our editorial of last month on "Automation, Revolution and Insight."

This month Martin Klein, Frank Williams and Harry Morgan of Rocketdyne continue their tremendous series with a discussion of "Multiplexing." If you aren't taking the time to read every one of their series, you are simply missing an opportunity to learn about a new and exciting field of instrumentation—digital techniques—via the clearest and best material ever developed on the subject. If you have missed any of these—go back and get: *Code Arithmetic* (Nov.); *Logical Networks* (Dec.); *Linear Programming* (Jan.); *Basic Digital Circuits* (Feb.).

As for the "Digital Ohmmeter" article, it teaches some fundamentals about bridges that every instrument man should know. That's why we selected it for you this month.

Chet Beard's article on "Valve Types and Characteristics" is 13 pages in length—but it covers most valve types now available, and its discussion on the methods for obtaining and using characteristic curves is basic.

Gosh, we nearly forgot to mention the MTI Radar article, to which we devoted the front cover. This article gives you a once over lightly (but thoroughly) on every important element in a radar system, plus the radar requirements for addition of MTI, plus the tests necessary for successful MTI operation. You'll find the instrumentation associated with these tests of interest, even if radar isn't your forte.

The editorial "Do You Really Know Your Instruments?" might stimulate your imagination. Just think of the practical and nice time you and your instrument men can have if you set up an educational program designed to answer the questions in that editorial.

All the above adds up to lots of practical instrumentation. Hope this finds you well and happy this month, and with enough relaxing time to partake of this repast.

Cordially,
Milt and the Editors

P. S. The practical-application program on the next page is HOT! Reserve your seat early.

*Dear Reader

Announcing the top Automation

AUTOMATION promises wonders for the future—but today there is a lack of trained manpower—there are not enough men available who are trained to work and think in the area of automatic production.

Manufacturers of automatic controls are faced with this problem in the application of their products in industry. Industrial executives cannot spare their engineers and production men the time to attend colleges and universities. Now—for the first time—a complete educational lecture-demonstration program is offered as a solution to these problems.

The Automation Show Management therefore offers

100 CLINIC SESSIONS

in conjunction with the THIRD INTERNATIONAL AUTOMATION EXPOSITION, November 26-30, 1956, New York, in the fields of

(1) Electronic Computers
(2) Process Automation
(3) Machine Tool Automation
(4) Office Automation
(5) Automatic Materials Handling (conveyors)
(6) Servomechanisms
(7) Electromechanical Components
(8) Electronic Components

Each clinic class will comprise a 90-minute *lecture and demonstration* based on *operating equipments* exhibited at the Exposition.

Each registrant can sign up for six clinic sessions in one (or more) of the eight basic fields.

For example, registrants to the Computer Clinic of the Second International Automation Exposition chose six of the following nine classes:

1. The Austin Co. (special-purpose computers)
2. Clevite-Brush (TapeDrum data handling)
3. Bendix Aviation (digital differential analyzers)
4. Berkeley-Beckman (analog computers)
5. Goodyear Aircraft Co. (analog computers)
6. Electronic Associates, Inc. (analog computers)
7. International Business Machines (digital data processors)
8. Librascope, Inc. (digital computers)
9. Teleregister Corp. (Magnetronic data systems)

Fill in card for early registration. Only 200 persons can be accommodated for any one field—for example, only 200 persons will be accepted for the computer clinic. Early registration is advised. Fee is $10.00 for six sessions. Each registrant will be given a choice of six sessions from the 100 available.

These clinic presentations will be at the applications level and thus instruct engineers, research men and technicians to specify, apply, and operate the components and equipments now available for plant, factory, laboratory and office automation.

Each clinic will consist of one 90-minute lecture and demonstration, by each of the participating firms, to a class of 30-35 registrants. This session will be delivered up to six times in order to ultimately reach the 200 registrants that will be accepted for any one clinic.

Each participating exhibitor is required to select the subject he wishes to present, and to outline the points he wishes to emphasize in his clinic session. In order to properly coordinate the subject matter presented by the exhibitors, and to avoid unnecessary duplication of emphasis or treatment by other exhibitors, the final selection of subjects will be made by the Clinic Director, Milton Aronson, Editor of INSTRUMENTS & AUTOMATION.

PREPARATION OF LECTURE

Each presentation will be prepared in advance in typewritten copy by the exhibitor. Illustrations and diagrams used in the lecture should be prepared in a form suitable for publication.

Although a blackboard will be available at each session, it is suggested that the basic points to be covered by the lecturer be prepared in advance on large, drawn illustrations.

A photographer will be available to photograph the exhibit and its accessories during the sessions at the request of the lecturer.

PUBLICATION OF PAPERS

The lecture papers or transcribed lectures will be edited by the Clinic Exhibitor and by the Clinic Director, both of whom reserve the right to delete any of the material. Nothing will appear in print that has not been approved by the Exhibitor, The Clinic Director and the Publisher of INSTRUMENTS & AUTOMATION magazine.

SELECTION OF CLINIC PARTICIPANTS

Each exhibitor participating in the Clinic will receive four-fold value:

A. Exhibit his products at the Third International Automation Exposition
B. Present lectures before six classes of Clinic Registrants
C. Have a feature article in INSTRUMENTS & AUTOMATION.*
D. Display and describe exhibited products in the *Automation Handbook* (25,000 copies of which will be published and distributed).

It is expected that advance requests for registration for the Clinics will exceed the number that can be accommodated in the six classes. Selection of registrants will be made on the basis of date of registration and equitable representation of the field.

100 exhibitors of the Automation Exposition can be accepted as participants in conducting these Clinics. As the Clinic sessions will receive widespread publicity before and after the Show is over, most manufacturers of instrumentation and automation products will wish to participate. Early reservation of facilities for these sessions is therefore essential.

---

*The Clinic Director reserves the right to select and edit the material for such publication as a feature article.

Educational Program of the Year
——100 CLINIC CLASSES

in the basic fields of

- Computers—analog, digital and special purpose
- Process Automation—transducers, monitors, controllers, data recorders, systems engineering
- Machine Tool Automation
- Office Automation
- Automatic Materials Handling
- Servomechanisms
- Electromechanical Components
- Electronic Components

Third International Automation Exposition
Advance Clinic Registration
845 Ridge Ave.
Pittsburgh 12, Penna.

Please expedite my registration for six clinic classes.
Attached is my $10 registration fee.

I prefer them to be in the field of ....
or divided between the fields of ....

Name ....
Title ....
Company ....
Address ....
Products Manufactured ....

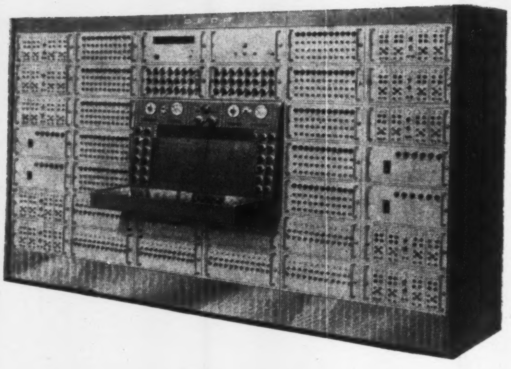


Fig. 1. New A14 expansible general-purpose analog computer combines functions of GEDA L3 and N3 units.

Basic Applications of ANALOG COMPUTERS

P. J. HERMANN, K. H. STARKS and **J. A. RUDOLPH**
Goodyear Aircraft Corporation

The industrial engineer can use the analog computer in one of three ways—using a mathematical-equation description of his problem, using a transfer-function description of his problem, or by establishing a computer circuit that acts like the elements in his problem. The second approach is of the greatest importance to industrial process control—and several examples are described.

A FEW years ago, a large manufacturer of electrical equipment found that the department specializing in heavy industrial drives of the Ward-Leonard type was experiencing an inordinately high ratio of engineering man-hours per unit sale, and that the ratio was increasing. Also, many individual sales resulted in losses or no profits. Customers' specifications often called for performance unobtainable with standard-stock motors, generators, and controls, and this often did not show up until the system was assembled. A large and frequent expense also resulted from the excessive field engineering required to eliminate hunting and other forms of instability after installation in customers' plants.

With the support of his department manager, an engineer in the plant recommended purchase of an analog computer. After a short learning program, the engineer began using the computer to solve problems for three different groups: for the sales engineering staff he was determining whether standard-stock items could be assembled into a system meeting a customer's requirements, thus permitting a lower bid than would ordinarily be made in many cases; for the development section he was solving actual system problems to find and define the controls required for optimum performance; and for the field engineering section he was determining the steps required to correct faulty systems already installed.

After about a year of operation, an informal cost study indicated that the computer was paying its way at the average rate of about $100.00 a day, excluding one problem solved soon after receipt of the machine which, it was estimated, saved more than the entire original cost of the computer, approximately $13,000.00

This experience, repeated with variations after almost every sale of a computer, suggests that every organization now using its engineering staff to solve dynamic problems should, for its own protection, study carefully the way these computers work and the benefit to be obtained. We believe that within five years almost every major industrial process or control system being installed will have been at least partially designed on an analog computer. Whenever industrial problems involve dynamic situations the analog computer can become a convenient tool.

Principle of Operation

The electronic differential analyzer, or analog computer, is an assembly of operational components of various types. The *direct-coupled direct-current amplifier* is the basic component used in most present-day general-purpose analog computers. By patching various external impedances to it, the amplifier can be made to perform

---

Presented at Second International Automation Show, Chicago, Ill., November 14-18, 1955.

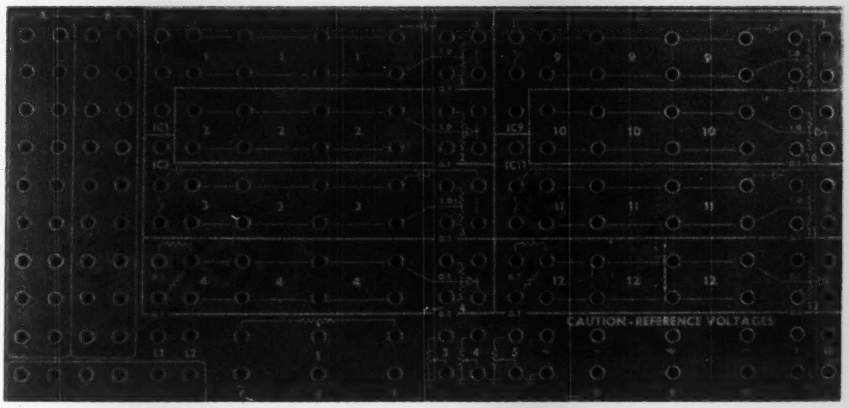


Fig. 2. Portion of problem board showing eight amplifiers (amplifiers 1 to 4 at left, 9 to 12 at right); potentiometers 3, 4, and 5 are shown at the bottom center; plus various resistors, capacitors, etc.

mathematical operations such as addition, sign changing, multiplication, integration, and differentiation. Fig. 3 shows how the direct-current amplifier (represented schematically by a triangle) is converted into a summing amplifier, an integrator, a differentiator, or into any desired operational unit. The computer is arranged for easy and rapid hook-up of built-in or external resistors, capacitors, etc., into these various operational circuits. Note that the d-c amplifier can be connected to perform as a differentiator or as an integrator. However, differentiating circuits have larger outputs for high-frequency signals and thus emphasise high-frequency noise pulses. Therefore, whenever possible, electronic integrators are used in preference to differentiators.

Whenever the product of two variables is required, multiplying devices other than a d-c amplifier (which can multiply by a constant only) are required. Two types of multiplying devices are used in analog computers, the electronic and the electromechanical, or servomultiplier (Fig. 4). The electromechanical multiplier is a variable-gain device consisting of servo-driven, mechanically-ganged potentiometers positioned in accordance with an input-voltage signal. Although accurate, the servomultiplier limits the range of operating frequencies because of the dynamics of the servomechanism components. The all-electronic multiplier responds to higher input frequencies than the electromechanical type, with accuracies in some cases that exceed that of the electromechanical type.

The Problem Board

Fig. 2 shows a portion of the problem board for the GEDA* L3 linear analog computer, a typical general-purpose analog computer. The d-c amplifiers are presented on the board with the same symbolic notation (triangular) used to represent an amplifier schematically.

Input and output jacks are available for each amplifier. A number of standard-value resistors are mounted permanently in the computer and are made available at the board. A number of potentiometers and a reference-voltage source are also available on the board. To supplement the fixed resistors built into the machine, fixed plug-in resistors and variable decade resistors supply many odd values of resistance that may be needed for solution of problems.

Fig. 5 shows amplifiers 2 and 3 (of Fig. 2) in greater detail. Note that amplifier 3 has a 1-microfarad capacitor permanently connected from the amplifier ouput to the input section; this is for easy conversion of the amplifier to an integrator merely by patching, as shown in Fig. 6.

Fig. 7 shows the patching required to make a sign changer of an amplifier such as No. 2 of Fig. 2. A plug-in resistor is under the input patch card.

---

*Reg TM, Goodyear Aircraft Corporation, Akron 15, Ohio.

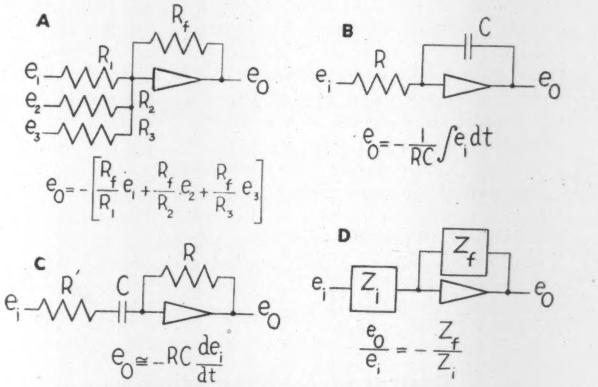

A
R_f
R_1
e_1
e_2
e_3
R_2
R_3
e_0
$e_0 = -\left[\frac{R_f}{R_1}e_1 + \frac{R_f}{R_2}e_2 + \frac{R_f}{R_3}e_3\right]$
B
C
R
e_i
e_0
$e_0 = -\frac{1}{RC}\int e_i\,dt$
C
R
R'
C
e_i
e_0
$e_0 \cong -RC\frac{de_i}{dt}$
D
Z_f
Z_i
e_i
e_0
$\frac{e_0}{e_i} = -\frac{Z_f}{Z_i}$

Fig. 3. Operational amplifier (represented by triangle) is converted into summing amplifier, integrator, differentiator, etc., by various feedback arrangements.

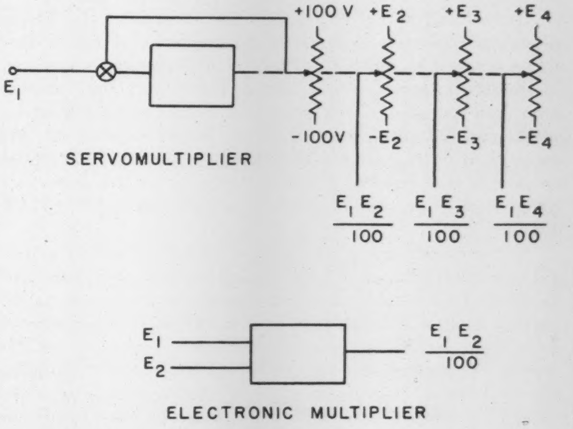


Fig. 4. The two basic types of multipliers used in analog computers—electronic and servomultiplier (electromechanical).

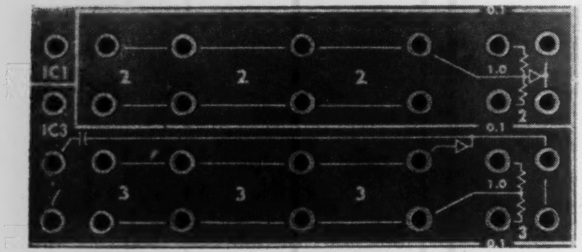


Fig. 5. Close-up of amplifiers 2 and 3. Amplifier 3 has 1-uf capacitor connected from amplifier output to amplifier-input jacks for rapid conversion of amplifier 3 into an integrator.

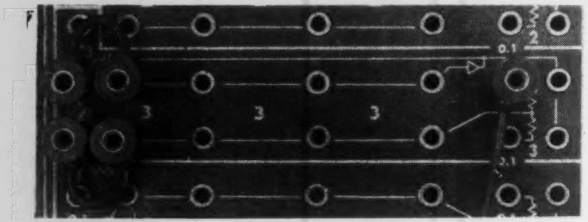


Fig. 6. Simple patching required to make amplifier 3 into an integrator. Jumpers at left simply close the input circuit; jumper at right is integrator output to next circuit.

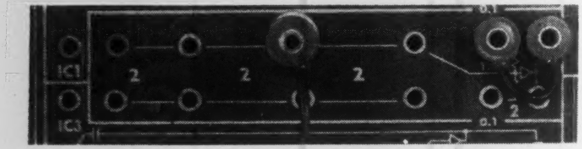


Fig. 7. Simple patching required to make amplifier 2 into a sign changer (amplifier with gain of -1). The 1-meg resistor at right is conected from the amplifier output to the input.

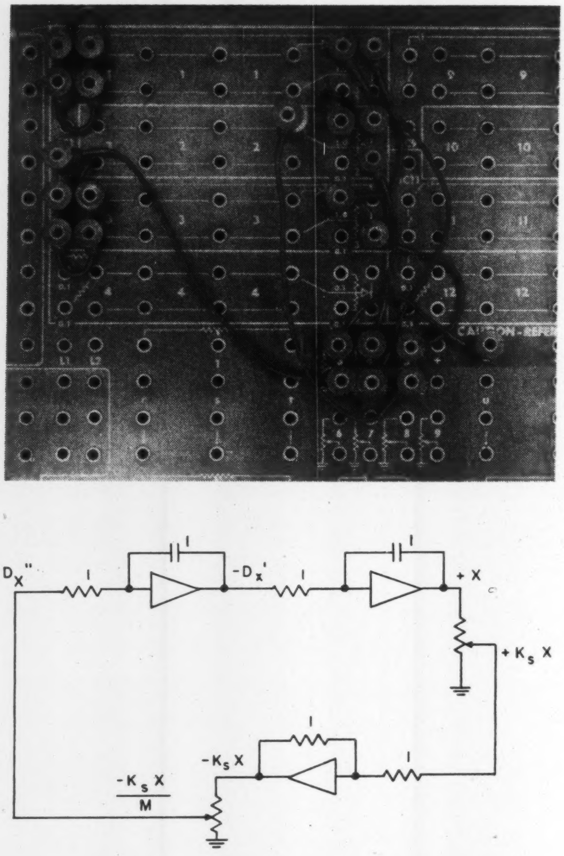


Fig. 8. Simulation of a simple spring-mass system. Bottom: wiring diagram; Top: necessary patching. (Note: $D_x'' = \ddot{x}$; $D_x' = \dot{x}$)

Basic Types of Problems

There are two basic approaches to the use of an analog computer. In the first, the system to be studied is expressed mathematically in differential-equation form. This approach is used often in design work.

The second approach, which may be called the block-diagram approach, represents all elements of the system to be studied by blocks, each of whose dynamic response is given in terms of a transfer function rather than a complete equation. *This approach is the most important for industrial situations involving processes that can not be defined by rigorous mathematical equations, but whose responses are known.* Several examples of the latter approach will be given after a simple example of the former.

The engineer using an analog computer wants a flexible instrument that he can adapt to his own uses and devices. The GEDA problem board, for instance, is designed so that a large proportion of the problem circuit patching, including components, can be done on the board. A particular example is an amplifier simulating the hydraulic transmission in a milling-machine setup that will be described. Ordinarily, three or four amplifiers are needed to simulate a second-order damped system. However, by setting up the complex circuit the transfer function is easily simulated across the one amplifier. The flexibility of the board allows the engineer to think of the simulation in terms of system components rather than differential equations, although it also makes problem setup somewhat more difficult.

Spring-Mass System

A simple spring-mass system described by the equation $M\ddot{x} + Kx = 0$ would be patched on the problem board in the following manner: The equation is rewritten in the form $\ddot{x} = -(K/M)x$ in order to perform integrations instead of differentiations. The problem wiring diagram is drawn as in Fig. 8. From the wiring diagram the problem is patched on the problem board by means of d-c amplifiers and other components. Fig. 8 shows the actual patching necessary for the solution of the problem.

An initial voltage charge placed across the second integrator will correspond to an initial displacement of the mass M. When the computer is placed in "operate," a continuous solution (with relation to time) of the displacement, velocity, and acceleration of the mass will take place. All solutions are in voltage form and can be recorded and evaluated.

Control of a Milling Machine

The simplified problem represented in Fig. 9 illustrates the application of analog computers to automatic-control problems. A milling machine is to be automatically controlled to cut a piece of material to the shape of a pattern. The cutting tool and the sensing probe are carried by the supporting framework. The probe rides lightly on the surface of the pattern and when the probe and cutting tool are in perfectly corresponding positions no error signal is sensed by the pickoff. If there is an error, the pickoff produces a voltage in the amplifier that supplies the control current to the hydraulic machinery positioning the cutting tool. The questions regarding the system are (1) can the system be stabilized? (2) is the speed response sufficient? (3) what should be the amplifier design? and (4) are any additional features necessary and desirable to meet specifications? A simulation by analog computer can answer these questions.

The first step is to draw a "picture" of the controlled system and to make certain component selections that will satisfy specifications of required power, torque, speed of response, physical size, etc. These selections will probably be made from catalogs of hydraulic equipment.

A block diagram of the proposed system is then prepared as shown in Fig. 10. The known component dynamics are shown in each block by transfer-function notation (they could also be shown by differential equations or by other methods that would describe the component action). The control amplifier is broken into separate actions representing lead, proportion, and lag in the control signal from the amplifier. Effectively, this is the control computer, and the relative amounts of rate, proportion, and integral signals are unknown. The values of the various K's must be determined so that a usable amplifier transfer-function can be established.

The next step is to draw a computer circuit. A preliminary circuit is shown in Fig. 11, along with the voltage scales. The control amplifier is simulated by four computing amplifiers (one each for the rate, proportion, and integral parts of the control signal, and one to add the parts together). The three parts of the control signal are put through potentiometers to allow for variation of the K's. The simulation function of each of the other computing amplifiers is indicated.

The next step is to operate the simulation. For purposes of demonstration, this circuit was altered to operate at a 1:100 time scale so that one second of system operation is represented by 100 seconds of computer simulation time. In this way we can display the results on a servo-driven X-Y plotter, which will display the response of the cutting tool position. It was found that additional hydraulic control loops were necessary to damp out the oscillations.

Backlash in the gears, hysteresis in the actuator, and saturation in the actuator and amplifier can be simulated. Nonlinearities in the hydraulic components also can be included in an analog-computer analysis.

Other Block-Diagram Problems

Fig. 12 shows a possible power-steering system for trucks or automobiles and includes all the dynamic elements important in determining the safety and stability of the system.

Fig. 13 shows a block diagram of a turbojet aircraft engine. The elements to be simulated are shown together with the connections between elements. The computer user can solve this problem nicely if he can insert transfer functions or equations in the blocks, or if this is impossible, if he can establish a computer circuit that acts like the block concerned. Note that he has three modes of attack.

A novel application—one involving concepts of the growing field of operations research—is illustrated by

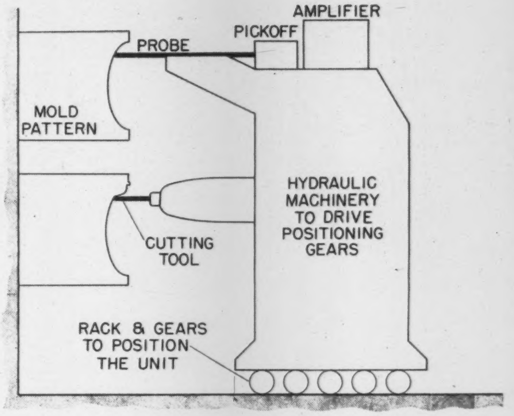

AMPLIFIER
PICKOFF
PROBE
MOLD PATTERN
HYDRAULIC MACHINERY TO DRIVE POSITIONING GEARS
CUTTING TOOL
RACK & GEARS TO POSITION THE UNIT

Fig 9. Milling-machine problem involves questions (1) can system be stabilized? (2) is response speed sufficient? (3) what amplifier is required?

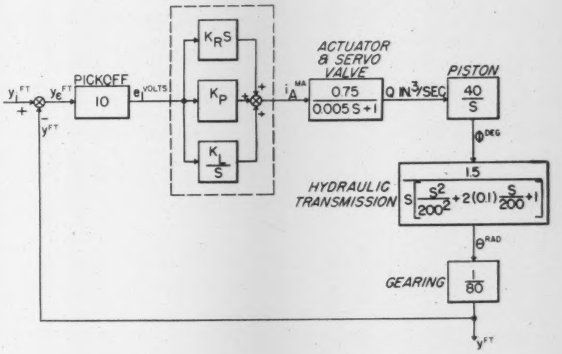

y_i^{FT}
y_e^{FT}
PICKOFF
10
e_I^{VOLTS}
$K_R S$
K_P
$\frac{K_I}{S}$
i_A^{MA}
ACTUATOR & SERVO VALVE
$\frac{0.75}{0.005S+1}$
Q IN³/SEC
PISTON
$\frac{40}{S}$
ϕ^{DEG}
HYDRAULIC TRANSMISSION
$\frac{1.5}{S\left[\frac{S^2}{200^2}+2(0.1)\frac{S}{200}+1\right]}$
θ^{RAD}
GEARING
$\frac{1}{80}$
y^{FT}

Fig. 10. Block diagram of milling-machine system with transfer-function description of each element.

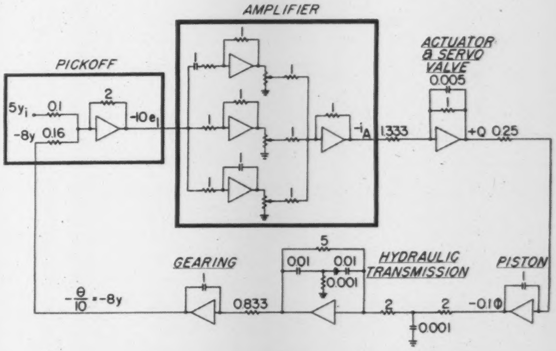

AMPLIFIER
PICKOFF
$5y_i$
0.1
$-8y$
0.16
2
$-10e_I$
$-i_A$
1.333
ACTUATOR & SERVO VALVE
0.005
+Q
0.25
GEARING
HYDRAULIC TRANSMISSION
PISTON
5
0.01
0.01
0.001
2
2
0.001
-0.1ϕ
0.833
$-\frac{\theta}{10}=-8y$

Fig. 11. Analog-computer diagram for system of Fig. 10 using 1:1 time scale. Final computer schematic used a 1:100 time scale (1 second of system operation corresponds to 100 seconds of computer simulation time) so that results can be plotted on an X-Y recorder.

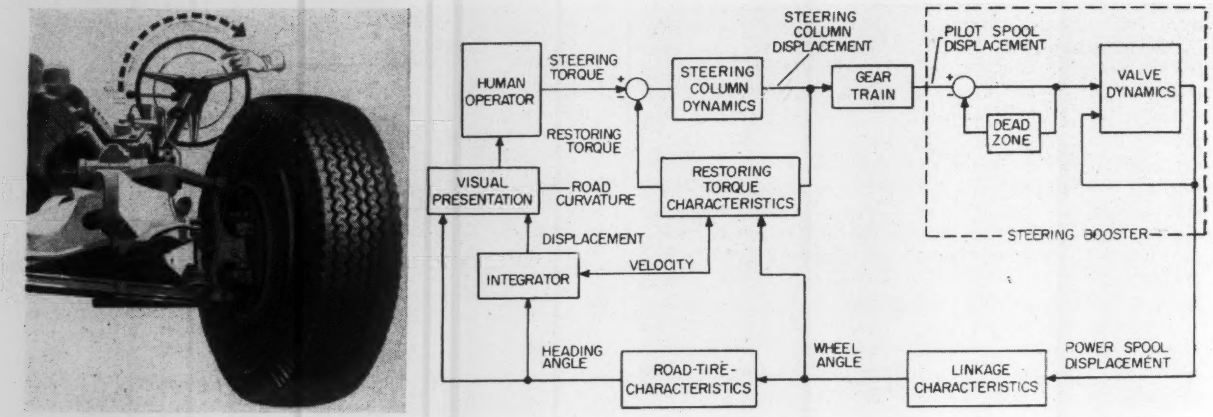

STEERING TORQUE
HUMAN OPERATOR
RESTORING TORQUE
STEERING COLUMN DISPLACEMENT
STEERING COLUMN DYNAMICS
GEAR TRAIN
PILOT SPOOL DISPLACEMENT
VALVE DYNAMICS
DEAD ZONE
VISUAL PRESENTATION
ROAD CURVATURE
RESTORING TORQUE CHARACTERISTICS
STEERING BOOSTER
DISPLACEMENT
INTEGRATOR
VELOCITY
HEADING ANGLE
ROAD-TIRE-CHARACTERISTICS
WHEEL ANGLE
LINKAGE CHARACTERISTICS
POWER SPOOL DISPLACEMENT

Fig. 12. Power-steering-system analysis.

Fig. 14, the block diagram for Goodyear Aircraft's economic power-dispatch computer.

The Answer

Fig. 15 illustrates the form of the "answer" that the analog computer produces. The computer variables that correspond to the variables in the physical problem exist in the computer as voltages. These voltages are brought out of the computer and are recorded on conventional chart recorders, usually of the multichannel type, or on two-axis plotters. The figure shows the computer solution to a power-industry problem recorded on a two-axis plotter. The computer calculated the power system "swing curves." The curves illustrate what happens to system stability as the time required to clear a fault increases.

Who Operates Analog Computers?

It is probably of interest to have some idea as to the kind of person required to operate analog computers. The popular conception is that he must be a Ph.D in mathematics, with long hair and a lost look. This is not so. A computer operator requires only a working knowledge of direct-current circuits, some mathematical ability and knowledge of differential equations, and a little aptitude for the operation of scientific equipment. *The real job is in setting up the original dynamic description of the system and in the analysis of the computer results in terms of the system.*

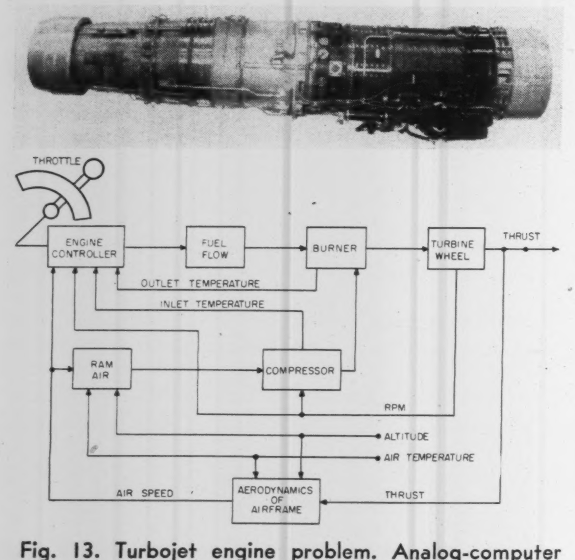

THROTTLE
ENGINE CONTROLLER
FUEL FLOW
BURNER
TURBINE WHEEL
THRUST
OUTLET TEMPERATURE
INLET TEMPERATURE
RAM AIR
COMPRESSOR
RPM
ALTITUDE
AIR TEMPERATURE
AIR SPEED
AERODYNAMICS OF AIRFRAME
THRUST

Fig. 13. Turbojet engine problem. Analog-computer operator can use either transfer functions or equations in each block—or he can establish a computer circuit that acts like the block concerned.

Since the definition of the problem is difficult, it is only fair to discuss it in some detail. The problem is associated intimately with the question of who shall operate the computer. Many prospective users of analog computers shy away because they feel that this difficult part cannot be handled in the ranks of their engineering department. One reason is that in the past all attempts to describe the relationships between a company's products on a strictly mathematical basis have been fruitless because of the magnitude of work involved in getting just one solution to the equations involved. Most generally, the equations are nonlinear and not susceptible to analysis by classical means. Realizing this, most engineering departments outside the aircraft and the electrical machinery industries abandoned mathematical analysis long ago. Now, however, the analog computer offers fast, convenient means to do all the hard work in the mathematical analysis. The operator must only state the problem; the computer will solve it. *Thus the person best qualified to use the computer in a given company is the engineer who knows that company's products and production processes, and is capable of describing the system units by block diagrams and equations or transfer functions.*

How To Get The Dynamic Characteristics

An important question facing the engineer solving these problems is how to obtain descriptions of dynamic characteristics for those parts of the block diagram not manufactured by his company or within his own plant. The component manufacturer cannot be relied on at present, for less than 20 percent of manufacturers supply transfer functions for the equipment they sell. Some do not know how; some know but will not for competitive reasons. Fortunately, the situation is improving as more and more users of analog computers begin insisting on this information before purchase orders are placed. Where the component supplier cannot supply dynamics information, the engineer must depend upon his ingenuity and ability to derive correct expressions for the relationships between input and output for the component. Again, this fact lends weight to the wisdom of assigning the computer to an engineer who is well versed in the practical aspects of the company's business.

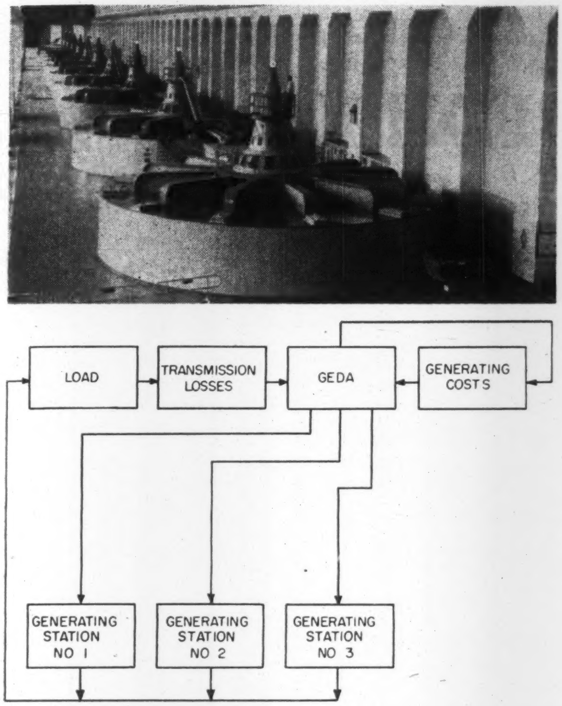


Fig. 14. Power-dispatch computer tells optimum operation of generating stations on basis of generating costs, transmission losses, and load.

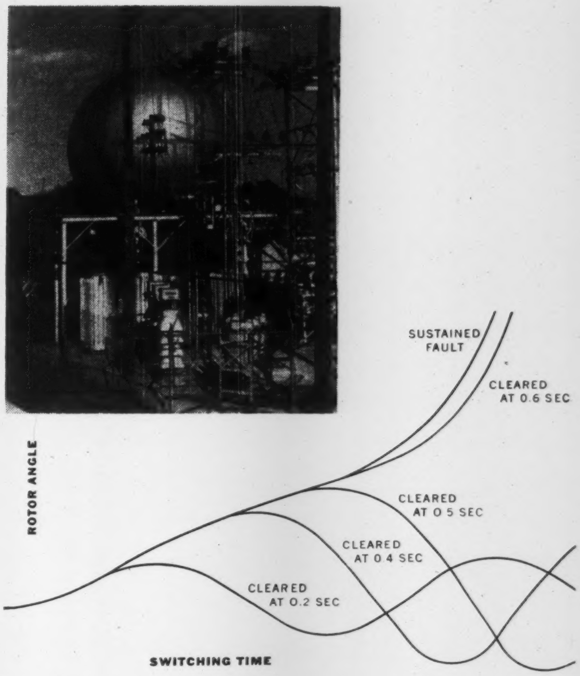


Fig. 15. Solution to a circuit-breaker problem.

Services of the Computer Manufacturer

How does the computer manufacturer help his customer or prospective customer? Most computer manufacturers make sure that the computer will be put to good use in the customer's plant. For example, Goodyear Aircraft maintains one of the country's largest analog-computing centers for the solution of dynamic engineering problems. The trained personnel of this laboratory analyze and solve sample problems for prospective customers provided that they are willing to participate personally in every step of the demonstration.

After the purchase and installation of a computer, Goodyear Aircraft provides instruction in the customer's plant, and emergency service during the life of the warranty. Every user receives copies of GEDA application reports as they are issued. The reports assist users to obtain maximum utilization of their computers; the best advertisement is an over-worked, productive computer. Reports are available covering the textile-mill problem (GER-6255), the power-system stability problem (GER-6731), the economic power-dispatch problem (GER-6969), and the automobile suspension problem (GER-5262) discussed previously.

In addition to these services, especially in the first year of operation, Goodyear Aircraft provides assistance in solving particularly difficult applications. After the first year, most users can set up and solve any problem they are likely to encounter.

Who Needs the Computer?

The basic appeals presented by the ability of the analog computer to solve engineering problems divide themselves into two types, those which appeal to engineers and those sought after by management. For the engineer, probably the most important appeal is that the analog computer provides a ready means for developing insight into the operation of complicated systems; any part of a system can be changed easily and the effects observed.

Closely allied with this factor is the ability of the engineer to "give his hunch a chance." How many new ideas have been lost in our industry because of the high costs involved in trying them? The computer gives a ready means for evaluating an idea during the study of the system and afterwards. A third appeal to the engineer is that this tool requires no new mathematics. The ability to write differential equations and transfer functions—standard tools of engineers of every specialty—is all that is required by way of formal training. As a matter of fact, any engineer can solve a simple problem on the analog computer after only two or three hours of instructions and familiarization. Also, the answers from the computer appear in the most familiar and meaningful way: graphical time plots of the performance of the system after a disturbance.

For management, the appeals naturally are somewhat different. Primarily they relate to the economics of production. Engineering costs are reduced significantly by application of the analog computer, and this type of computer is so low in cost that a saving of one top engineer's pay for a year can pay for the basic machine. Furthermore, in this day of extreme shortages of experienced engineers, the analog computer permits work output which otherwise could not be achieved. A second important appeal is that the manufacturer's end-product is improved, providing a competitive advantage. *And, of real practical importance, present personnel are usually the best qualified operators of the computer.*

DIGITAL AUTOMATION—No. 6

MULTIPLEXING

MARTIN L. KLEIN, FRANK K. WILLIAMS and **HARRY C. MORGAN**
Rocketdyne Div., North American Aviation, Inc.

Multiplexing is often the solution to the problem of handling many channels of data. Here are the fundamentals of fixed-time and demand multiplexing, both electromechanical and electronic. The principles are illustrated in the design of typical multiplexers of both types. The importance of clamping is emphasized.

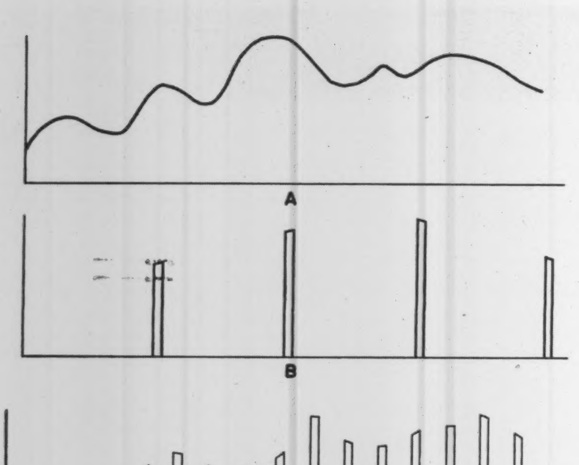


Fig. 6-1. Curve represents analog signal. Rate at which analog signal (A) is sampled and duration of sampling interval determine the amount of signal that is lost between sampling intervals. Less signal is lost when sampling rate is high, as in D.

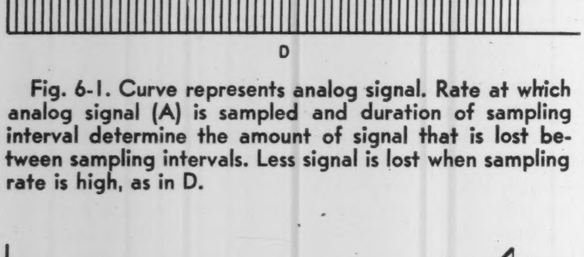


Fig. 6-2. Technique for multiplexing of two information channels. Note intermixed output.

MULTIPLEXING is needed for the simultaneous transmission of many independent pieces of information. Multiplexing—the time sharing of a single transmission channel by several independent information sources—allows a reduction in the amount of equipment used for the transmission and processing of this information. For example, suppose two hundred separate telephone conversations are taking place simultaneously. The simplest way to transmit this information without interference among the conversations is to use two hundred pairs of wires and associated amplifying equipment. This works admirably, but requires extensive equipment.

One method for reducing the equipment is to place each narrow-band conversation on a separate carrier frequency and to transmit this wide-band signal over a single pair of wires with a single amplifier; the information could be separated and channeled to the appropriate receivers by filters. Although this reduces the amount of equipment, the number of conversations that can be accomodated using separate carriers is limited because carrier frequencies must be used which will not allow the information to intermix and which can be separated easily. This method is used in actual information transmission in some telemetering systems; however, multiplexing of the information offers several advantages.

A true multiplexing system allows the same equipment to be time-shared by the many separate information channels—that is, information from Channel 1 occupies the equipment for a small interval of time; it is then locked out of the equipment and information from Channel 2 occupies the line and equipment; then Channel 3 uses the equipment, and so on until the cycle repeats itself. In this method of information handling, information from the various channels is lost during the time it is locked out of the system. On the other hand, the amount of equipment needed to handle and process the information is held at a minimum.

As information is lost when the signal is locked out of the equipment, the rate at which the information is to be locked in and out of the circuit becomes the measure of how much information is retained and how much lost. Fig. 6-1,A shows an arbitrary piece of analog information possibly representing a telephonic conversation or the output of a transducer. If we use the commutation or multiplexing pattern of B we see that a considerable amount of information is lost because the sampling intervals are widely separated. However, during the time in which the signal is sampled, we receive *all* of the information from the channel.

Figs. 6-1 C and D show other commutation programs using rapid and short intervals for examining the information. The more rapid the interval, the less the amount of lost information.

Fig. 6-2 shows how two separate information channels are multiplexed to produce an intermixed output which first represents the information in transducer 1 and then in transducer 2, alternately. This is a true multiplexing system in that the output and subsequent equipment is alternated between the two independent sources of information. Somewhere further along the line the two independent channels must be separated from one another so that the separate pieces of information are available independently.

It is possible to commutate or multiplex in two distinctly separate manners. These are:

1. Fixed time intervals
2. On demand by information rate

Fixed-Time Multiplexing

With a fixed-time multiplexing system, the commutator is driven by a clock device which alternates the information from the separate channels at fixed, preset time intervals. In this application the rate of commutation is established by the designer, and the clock establishes the rate of switching between the independent inputs.

Fig. 6-3 shows a simple example of this type of commutation. Each of the four inputs to the matrix carries a separate, independent signal. The switches on the side are pulsed at fixed intervals by a clock into positions 00, 01, 10, 11; when the switches are filled, the cycle repeats itself. As this is essentially a binary-decimal matrix, the verticle lines 0, 1, 2, and 3 are activated in succession, and the common output sees the four separate input signals in succession.

This is a simple and workable multiplexing device. Note that the rate of commutation is fixed by the rate at which the switches are changed. This type of commutator can step from a rate as slow as we desire up to a maximum rate of about 50 steps/second.

Demand Multiplexing

An alternate method of commutation is demand or "commutation by exception" multiplexing. Fig. 6-4 shows signals that do not change for intervals, and then change rapidly for short intervals of time. When the signals are unchanging, we may not be interested in them because everything is progressing in order. However, when a signal starts changing rapidly, we wish to lock it in and hold it until it stops changing. In Fig. 6-4, signal 1 is delivered to the output *only when it is changing;* signal 2 is delivered to the output at *all other times.*

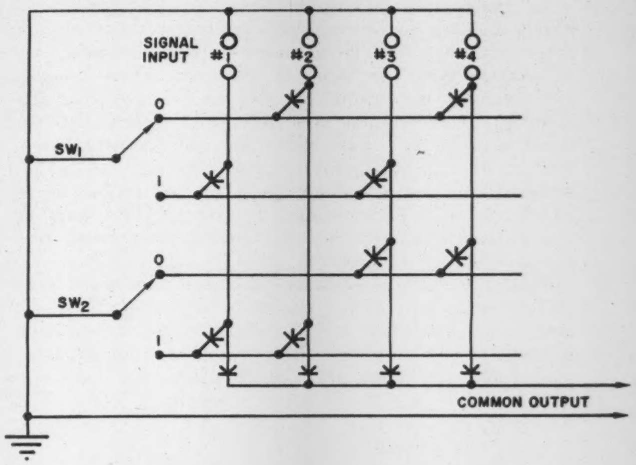


Fig. 6-3. In fixed-time multiplexing by a diode matrix, the matrix switches are operated by clocks into positions 00, 01, 10, and 11, in succession. The common output thus receives the four separate input signals successively, but at different times.

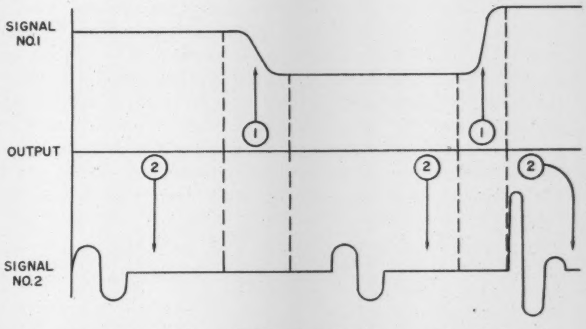


Fig. 6-4. Demand multiplexing locks on signal 1 only when signal is changing, and ignores it when not changing. Alternate channel (2) is sampled whenever open—that is, when channel 1 is not being sampled.

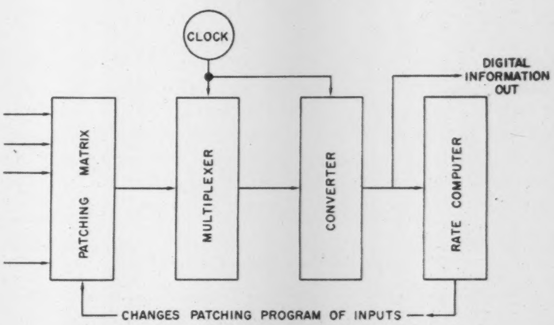


Fig. 6-5. Demand-multiplexing program requires a rate computer to establish when rate of signal exceeds preset rate—at which time the computer over-rides the clock in controlling the matrix to hold desired channel on the output.

An example of this would be a chemical process in which we are concerned with a temperature and a pressure. When the temperature is not changing, we will not be concerned with it. However, when it starts increasing or decreasing rapidly, we wish to keep examining it and ignore the pressure. Alternately, we could arrange the same thing for the pressure information. If both temperature and pressure change together significantly, we are in a bit of trouble as to which one is to be examined. In this case, for want of a better alternative, we could revert to a fixed rate (clock fixed) commutation.

This demand or exception program requires a subsidiary computer (of the analog or digital type) which determines when the *rate of change* of the information exceeds a pre-set value. This computer output takes precedence over the clock (which drives the commutator) and becomes the demand controlling factor. Fig. 6-5 shows in block form the operation of such a demand commutating program.

Electromechanical Multiplexing

Slow-speed commutation can be accomplished using relays driven by either of the basic methods described —fixed time or demand. The relay commutation method is satisfactory for commutation speeds up to about 50 per second. Thus we could multiplex 50 channels at a fixed rate, visiting each one for 1/50 of a second at 1-second intervals; 25 channels could be visited twice a second; 200 channels of information could be visited at a fixed rate of 1 visit every 4 seconds; and so on. In slowly varying industrial processes, this type of commutation is entirely satisfactory. It is equally useful for high- or low-level information signals and is essentially a making and breaking of circuit connections.

Fig. 6-6 shows the typical *Christmas-tree* circuit used for electromechanical multiplexing. This Christmas-tree relay circuit connects each input in turn to the common output. Three relays are used. The first has 4 double-throw sets of contacts to the 8 inputs; the second has 2 sets of simultaneously actuated contacts; the third has 1 set of contacts. If we continued this Christmas-tree pattern, the fourth would have 8 sets of contacts. In short, we follow the binary number of pattern as far as the tree extends, with contacts of 1, 2, 4, 8, 16, 32, 64, etc. The contacts are of the single-pole double-throw type, as shown.

The relays are actuated with binary code. With no input pulse the 3 relays are in the 000 condition and input 0 is connected to the output. The first pulse throws the first relay, reading 001, and delivering input 1 to the output. The second pulse reads 010, throwing out the first relay and throwing in the second. The third pulse reads 011, the fourth 100, and so. The result is, as can be seen by following through the Christmas-tree contacts, each input of the eight shown is connected in turn to the common output. At any one time, one and only one is connected. Only one piece of information at a time is allowed through the tree.

Separating the Output

Suppose we wish to "process" data from many channels. (The processing may include amplification, conversion from d-c to a-c form, conversion from analog to digital form, or any of the things normally performed on data.) Fig. 6-7 shows a complete multiplexing and demultiplexing system which accepts the inputs of 8 channels, feeds the multiplexed signal to the single processing unit (which may be an amplifier, converter, etc.), and then separates the output into 8 separate outputs each representing the information from the corresponding input. We simply synchronize the output tree wit the input tree, and the information feeds separatel through the output lines corresponding to the input.

We have in Fig. 6-7 a slow-speed multiplexing syste which is entirely useful. Fig. 6-8 shows a practical circuit for supplying the binary counts for the relays fro a chain of flip flops. The three flip flops shown ar driven, say, at a fixed rate of 10 steps a second fro a relaxation circuit. The flip flops count from 000 t 111 and then repeat. The output of the flip flop goe to a cathode follower which drives the relays of th Christmas-tree multiplexer.

The relays of the multiplexing tree and those of th separating tree are placed in series in the cathode fo-

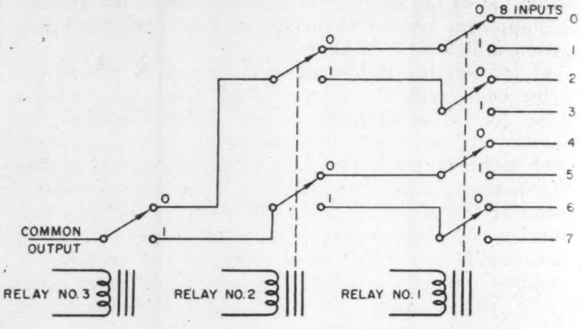


Fig. 6-6. Typical Christmas-tree relay circuit for electromechanical multiplexing of 8 channels. Relays are shown in position 000, and input 0 is delivered to output. First input pulse would trip relay 1 (corresponding to condition 001) and deliver output 1 to common output. Similarly, the seventh successive pulse would trigger all three relays (corresponding to condition 111) and deliver channel 7 to output.

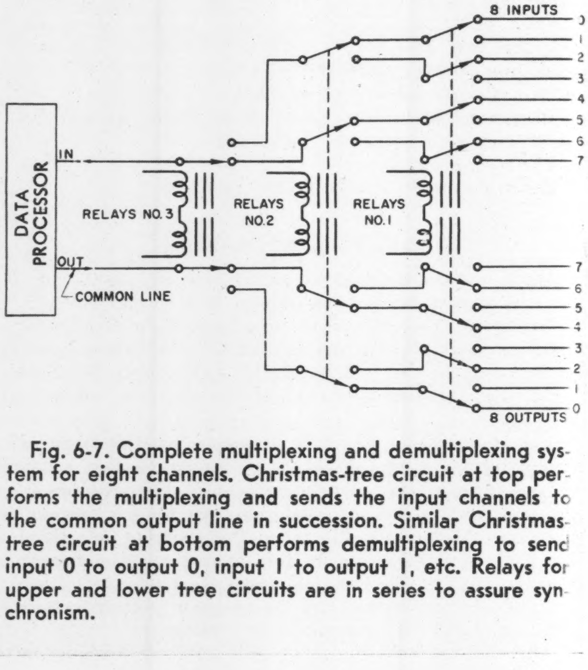


Fig. 6-7. Complete multiplexing and demultiplexing system for eight channels. Christmas-tree circuit at top performs the multiplexing and sends the input channels to the common output line in succession. Similar Christmas-tree circuit at bottom performs demultiplexing to send input 0 to output 0, input 1 to output 1, etc. Relays for upper and lower tree circuits are in series to assure synchronism.

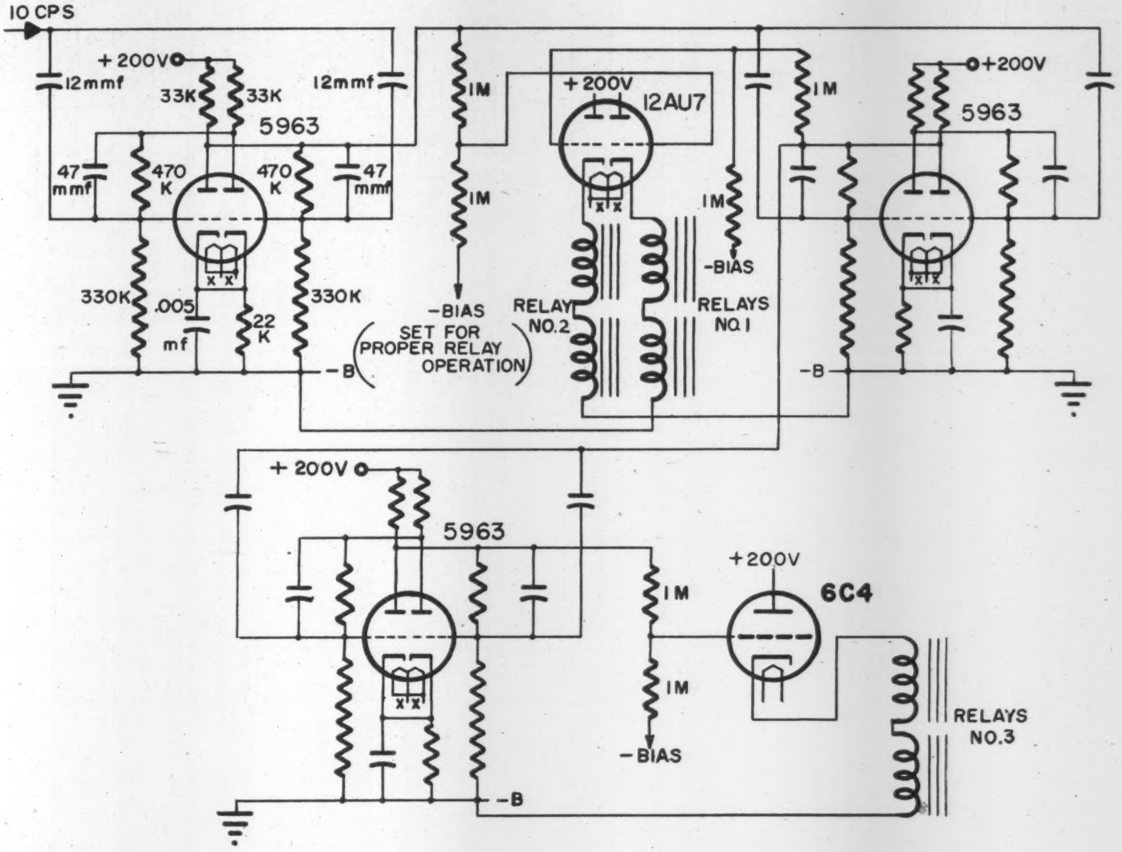


Fig. 6-8. Circuit for driving the relays of the system shown in Fig. 6-7. The three flip-flops are driven by a 10-cps input signal, counting from 000 to 111 and then repeating. The output signals from the flip-flops drive cathode followers which drive the relays of the Christmas-tree multiplexing and demultiplexing system. Note that the relays of the multiplexing and demultiplexing trees are in series and must operate simultaneously.

lower circuits, and are operated by the same signal from the flip flop. This assures synchronism, and as a result the inputs are fed serially through the common line and then separated back onto separate output lines by the demultiplexing tree. Note that at the counting rate of ten counts per second, we "see" each of the eight channels every 0.8 of a second for an interval of 0.1 of a second.

Comparison of Christmas-Tree-Relay and Diode-Matrix Multiplexers

This Christmas-tree relay performs the same functions as the diode matrices described previously.

For comparison, the same multiplexing operation is shown with a diode matrix in Fig. 6-9. The diode matrix counts with the same flip flops used for the Christmas-tree-relay matrix and feeds the eight inputs serially to the common line, processes the information, then separates it to the eight separate outputs again. Unlike the relay matrix, however, the diode matrix can step at speeds up to several million steps per second.

Frequency Response

A logical question at this point is: to what frequency response does this commutation rate correspond? Or, how fast must we commutate in order to obtain all the information in a bandwidth of 0 to 300 cps? 0 to 2 cps? A rise time of 0.2 sec? We will postpone these questions for consideration in the chapter on *Information Theory;* suffice it to say at this time that corresponding to every frequency and rise time on which we wish to obtain information, there is a certain commutation rate at which the multiplexer must step to obtain the information we desire to the accuracy we desire.

Design of a Practical Diode-Matrix with Electronic Multiplexing

The diode matrix (Fig. 6-9) is generally a more suitable method for multiplexing than the relay matrix (Fig. 6-7). Being all electronic, it has no moving parts to go out of order, has a wider range of operational speed, and is simpler to program. As a disadvantage, it requires a relatively high-level signal because diode noise in the circuit feeds through the matrix.

Suppose it is desired to multiplex three separate inputs to a common line for subsequent operations. Let us assume that the commutation rate should be as follows:

Channel 1—visit every 0.0010 second (1 ms)
Channel 2—visit every 0.0010 second (1 ms)
Channel 3—visit every 0.0005 second (½ ms)

These considerations (as we will see in a following chapter on *Information Theory*) correspond to certain rise times and information rates. Channel 3 must be visited more often because the rise time of the signal in Channel 3 is faster than the other two. We are also

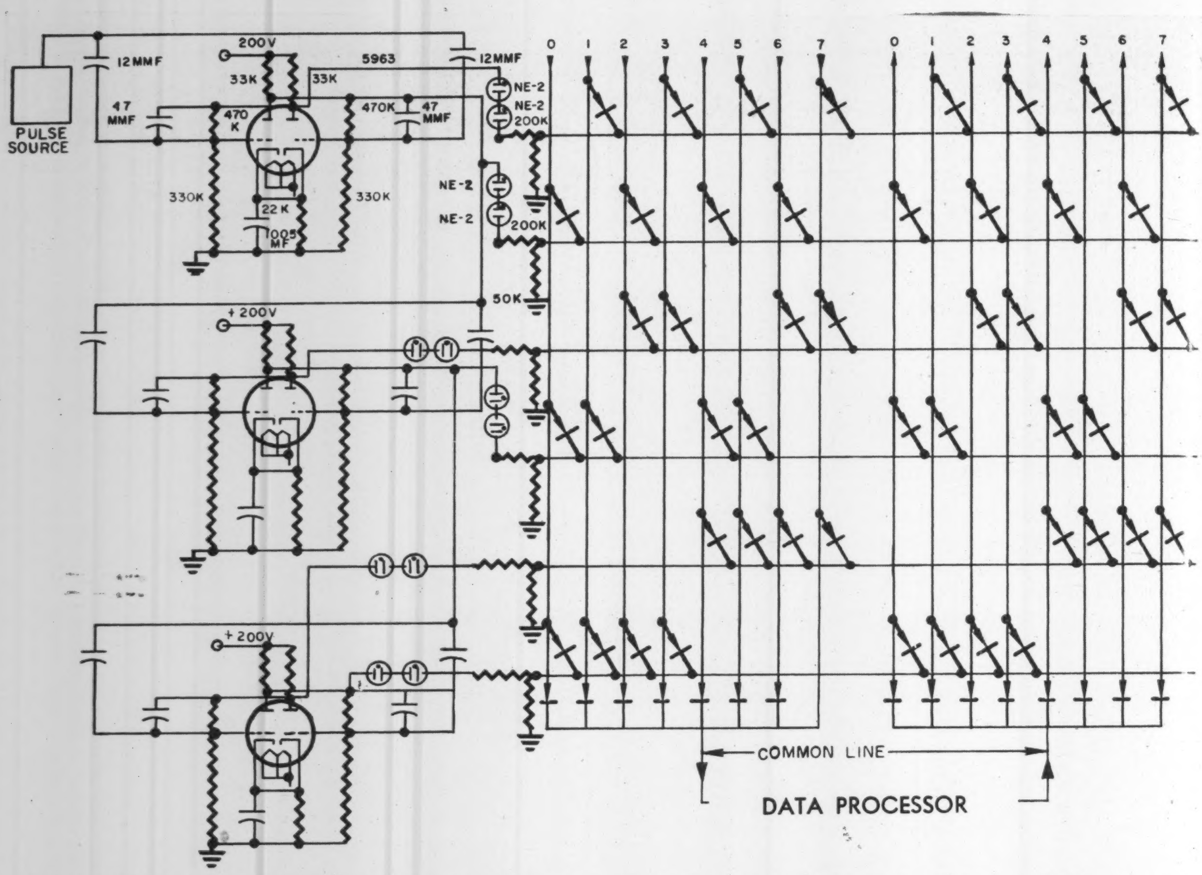


Fig. 6-9. Diode matrix for performing the same function as Fig. 6-7—that is, multiplexing eight input channels, and delivering the single-channel multiplexed signals to the eight appropriate outputs. Basic advantage of diode matrix over Christmas-tree relay circuit is higher speed.

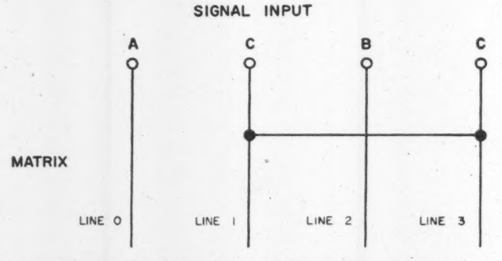


Fig. 6-10. A diode matrix of four lines is required to multiplex three input channels if one of the channels is to be visited twice as often as the other two. Channel A is visited by line 0; channel B by line 2; but channel C by lines 1 and 3. Therefore, if matrix is operated in succession, the signal inputs will appear at the common output in following order: A-C-B-C-A-C-B-C—.

to drive this matrix from a fixed clock whose frequency we must determine. The full-scale input of each channel is assumed to be 0-100 millivolts.

Our first consideration is how many lines are necessary in the matrix? This is dictated by the visitation program set up for the three channels. The input patching shown in Fig. 6-10 shows that 4 lines in the matrix are needed for the 3 inputs. It shows that if we step among the four inputs at a rate of 0.00025 second, we will visit Channel A every fourth step, which is 4 x 0.00025 or 0.0010 second. The same program holds for Channel B. However, Channel C is visited every other step (first by line 1 and then by line 3) or every 2 x 0.00025, or 0.0005 second. Therefore, we have established the visitation program required.

Our next consideration is whether to use an electronic or electromechanical Christmas-tree arrangement. The stepping rate of 0.00025 second per step precludes the possibility of any electromechanical device because 1/0.00025 second equals 4000 steps per second.

The full-scale inputs of 0-100 mv are relatively low-level signals which do not appear encouraging for using a diode matrix. However, it can be used here if it is used merely as a gating control device. We will proceed with the design of the matrix and make a small modification to accomodate these low-level input signals.

As the stepping rate is 4,000 per second we will require a multivibrator or oscillator running at this rate. There are four inputs; in binary numbers we can express them as input 00, 01, 10, 11. Two flip-flops in series are required to provide this count of four in binary. Fig. 6-11 shows the flip-flop clock and matrix in diagrammatic form. This circuitry provides the necessary counting rate and the required number of inputs if they are patched with the input channels as shown.

The problem now is the low level of the input signal and the switching transients of the diodes (which would pass through the matrix along with the input signal as

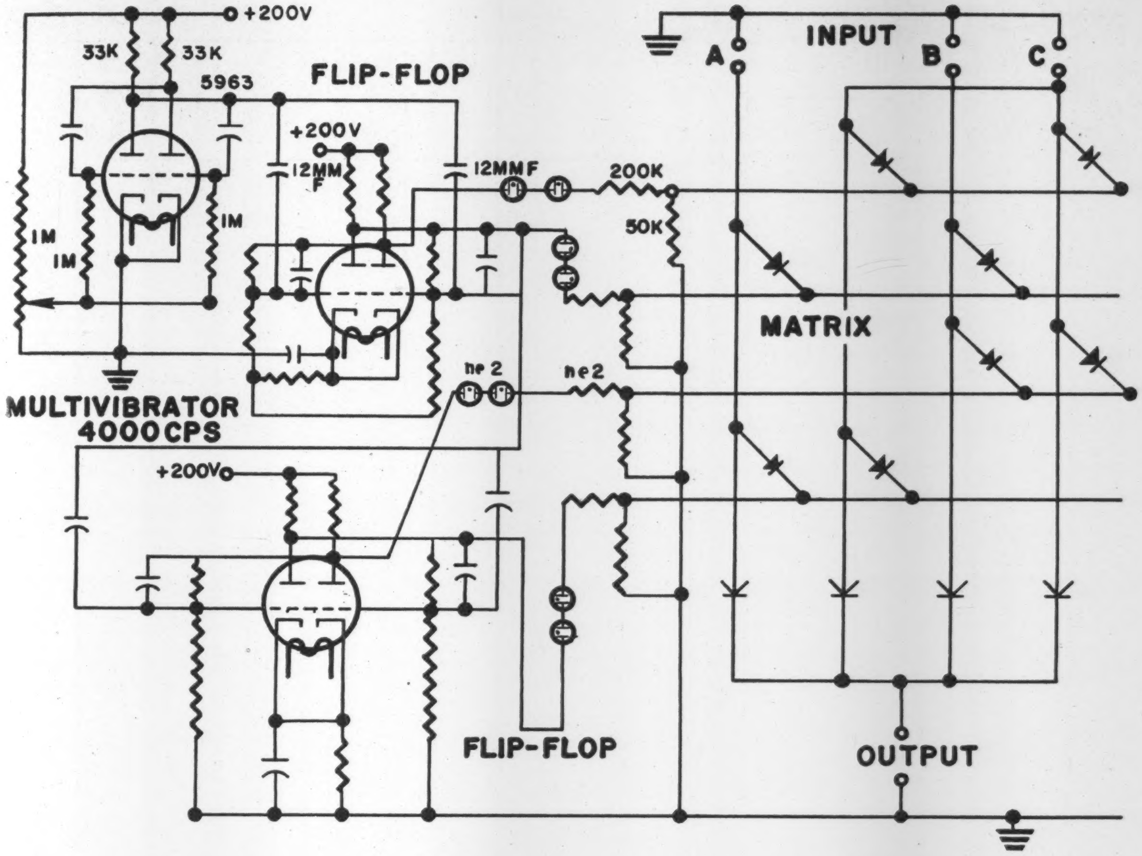


Fig. 6-11. Flip-flop clock and matrix for multiplexing the 3 inputs so that channel A is visited every 1 ms, channel B every 1 ms, and channel C every 0.5 ms.

distortion or noise). To circumvent this problem, we could amplify each of the inputs to a higher level of, say, 1 volt. An alternate plan is to use the matrix to gate the inputs only, pasing the inputs through gating tubes.

Fig. 6-12 shows a low-level multiplexer with 4 gating tubes receiving the 4 input signals. The vertical matrix lines are connected to the screen grids of the gating tubes, turning them on alternately at a rate fixed by the flip-flop clock. This permits the 4 inputs to pass in turn through the gating tubes to the common output. In addition, the pentodes amplify the inputs.

The scheme used can be extended to any number of inputs without difficulty. Thus, eight inputs could be accommodated with eight vertical lines, eight gating tubes, and three flip-flops. One hundred twenty-eight inputs require seven flip-flops and 128 gating tubes and vertical lines.

Note that the numbers used are generally binary numbers because the binary circuitry is simple; decimal quantities, such as 1, 10, or 100 inputs, require feedback circuitry in combination with the binary circuitry. It is generally easier to operate in binary numbers and allow a few channels to remain idle. For example, if 9 channels are required, it is more economical from the point of view of construction and maintenance to operate seven flip-flops in a matrix that counts to 128 and omit the last 30 counts than to construct the feedback circuitry to count to 100 and omit only two.

Design of a Slower Electromechanical Multiplexer

Let us now design a slow-speed multiplexer for an industrial process whose variables can be multiplexed over an interval of time that does not require high-speed electronic multiplexing. The process under consideration is to multiplex the following channels to a common output:

Channel A— 8 seconds between visits
Channel B—16 seconds between visits
Channel C—32 seconds between visits
Input level: 0 to 1 volt full scale.

The first step, as before, is to arrive at the number of channels necessary to obtain the multiplexing program. All of the visiting intervals are divisible by 4, which immediately suggests itself as the stepping rate. The following patching program, using a 4-second stepping rate is also suggested:

Channel Patching

Input	Channel
1	A
2	C
3	A
4	B
5	A
6	C
7	A
8	blank

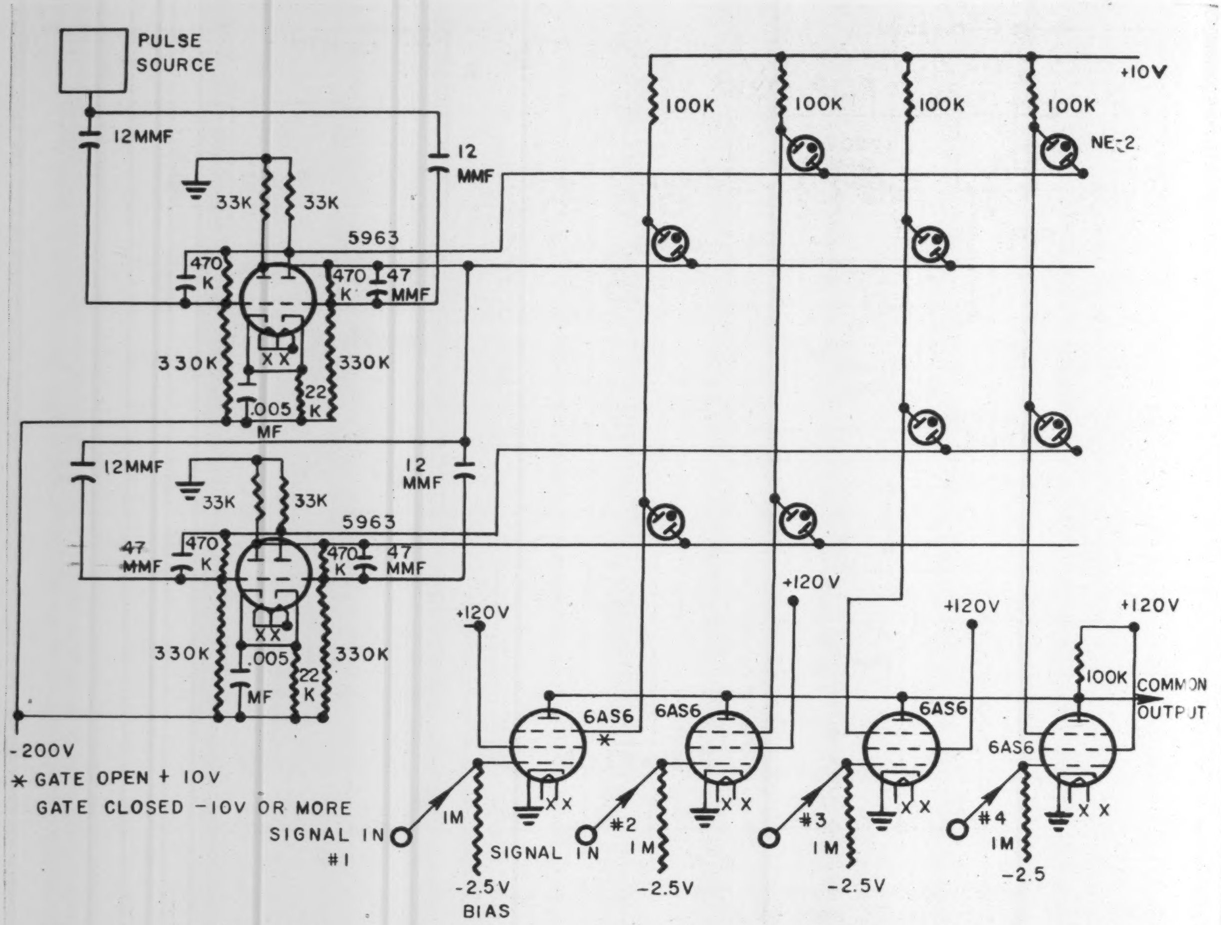

PULSE SOURCE
12MMF
12 MMF
33K
33K
5963
470 K
470 K
47 MMF
330K
330K
XX
.005 MF
22 K
12MMF
12 MMF
33K
33K
5963
47 MMF
470 K
470 K
47 MMF
330K
330K
XX
.005 MF
22 K
-200V
∗ GATE OPEN + 10V
GATE CLOSED -10V OR MORE
+10V
100K
100K
100K
100K
NE-2
+120V
+120V
+120V
+120V
100K
COMMON OUTPUT
6AS6
6AS6
6AS6
6AS6
∗
XX
XX
XX
XX
SIGNAL IN #1
1M
-2.5V BIAS
#2
SIGNAL IN
1M
-2.5V
#3
1M
-2.5V
#4
1M
-2.5

Fig. 6-12. Low-level multiplexer uses low-level input signal to gate pentodes at bottom of each matrix line. Signal on matrix line raises suppressor voltage of gate tube, enabling the low-level input signal to be amplified and appear at common output. (Self bias in cathode of 6AS6 can be used instead of 2.5V fixed bias.)

Only seven channels are required, but to maintain binary count and keep equal time intervals between visits, an extra (blank) step was added. As eight steps per cycle of visits are used, this suggests an eight-count system. The stepping rate allows the use of either electromechanical or electronic systems. This is equally true for the input signal voltage. We will arbitrarily make use of electromechanical devices (Fig. 6-13).

The clock will operate at one count every four seconds and will drive a chain of three flip-flops which therefore count to eight—or in binary, 000-111. The electromechanical system will be a Christmas-tree chain using three separate relays (Fig. 6-13). One relay has a double-throw single-pole contact, another relay has two sets of contacts, and the third has four, as explained previously. Each relay is driven by a cathode follower.

The circuit in Fig. 6-13 performs the multiplexing program. The eighth channel can be left blank or, as is customary, a standard voltage can be applied as a check. This standard voltage is a measure of the system accuracy during the course of the run so that if everything remains in correct operational form, the standard voltage is read out every eighth step. This is not a guarantee that the readings taken on the other seven are all correct, but it is some measure of protection and puts an idle channel to good use.

Clamping

The operation of clamping is essentially that of examining the analog signal for a fixed interval and then holding, say, the peak value reached in that interval for an indefinite interval of time. Fig. 6-14 shows an analog signal which is examined briefly at fixed intervals of time. The peak value is held until the next clamp sample.

Note that the analog signal is effectively disconnected from its circuit during the clamp interval, and the fixed peak value is transferred during that interval. This circuit could be simply a single-pole double-throw switch, which is closed and opened at fixed intervals, and connected to a capacitor. We could close the circuit for a short time and allow the capacitor to charge up. When the switch is opened, the capacitor will hold its charge. The switch is then thrown to the ground position, which discharges the capacitor and makes it ready to receive the next sample of signal (when the switch is connected to the analog signal again).

This use of an electromechanical relay is practical. Generally, however, this clamping action is more easily accomplished with all-electronic circuitry, whether the clamp is fast-acting or slow-acting.

Clamping an analog signal is required in the conversion from analog to digital form. This process of con-

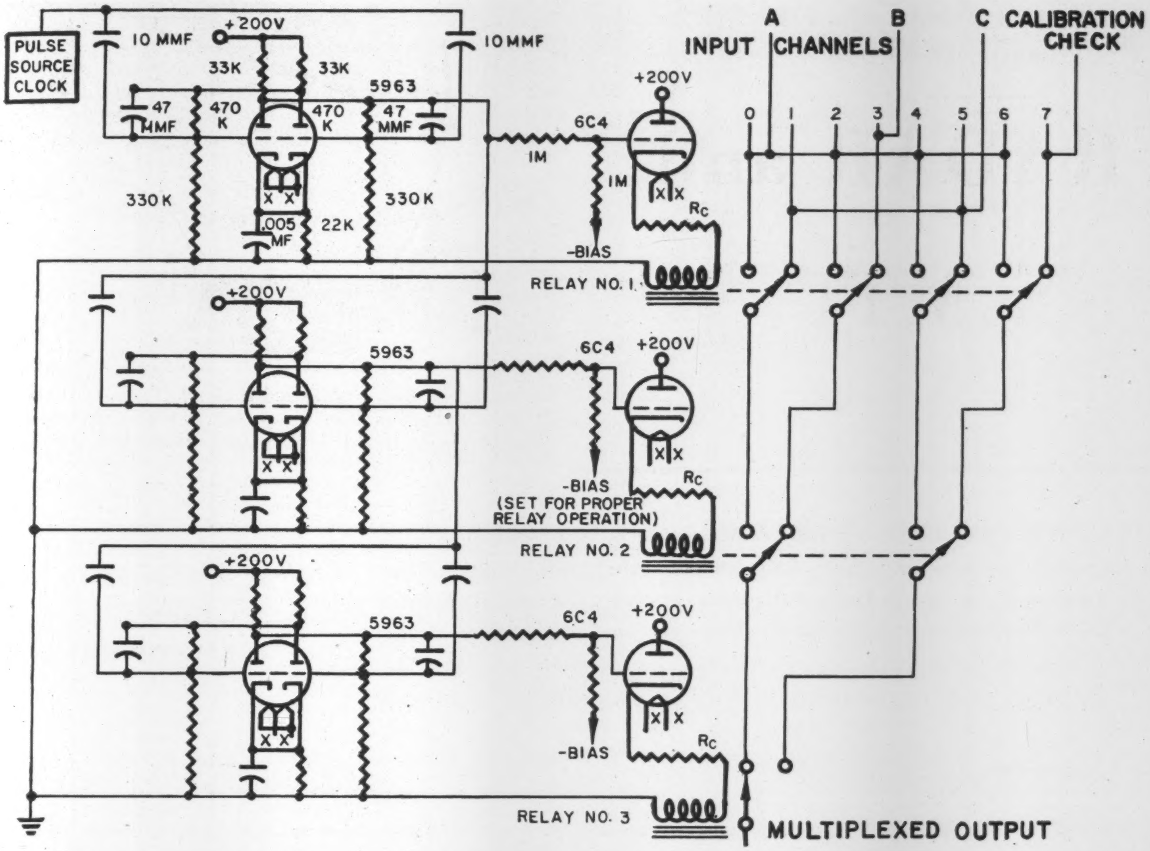

PULSE SOURCE CLOCK
10 MMF
+200V
33K
33K
10MMF
5963
47 MMF
470 K
470 K
47 MMF
330K
330K
.005 MF
22K
X X
1M
6C4
1M
+200V
X X
Rc
-BIAS
RELAY NO. 1
+200V
5963
6C4
+200V
-BIAS (SET FOR PROPER RELAY OPERATION)
Rc
RELAY NO. 2
+200V
5963
6C4
+200V
-BIAS
Rc
RELAY NO. 3
A
B
C CALIBRATION CHECK
INPUT CHANNELS
0
1
2
3
4
5
6
7
MULTIPLEXED OUTPUT

Fig. 6-13. Christmas-tree-type electromechanical (relay) multiplexer for switching input A, B, C, to output in following order: A-C-A-B-A-C-A-blank——. The pulse source establishes the basic rate. The 3 flip-flops operate the multiplexer relays in proper order (000 to 111) to deliver the inputs to the output in the desired succession.

version takes a short but finite interval. If a digital conversion is to be made, a fixed value must be maintained during the interval required for the conversion. As the interval is finite, the signal moves before a conversion is completed. Obviously, the digital reading is never exactly that of the analog signal.

The conversion equipment must be capable of retaining a fixed and unchanging signal during the conversion interval; if not, a meaningless digitization of the analog signal results. This is the function of the clamp.

Clamp Used with Multiplexer

The clamp is usually used in conjunction with the multiplexer described previously. The composite over-all operation of a multiplexer and clamp is shown in Fig. 6-15. Here analog traces from two input channels are shown. These signals are fed to a multiplexer which commutates the two signals successively as explained previously. The common output of the multiplexer is then clamped—that is, the clamp examines the successive inputs of the two channels for short periods of time, clamps the values at fixed intervals, and holds this value until the next step of the multiplexing device.

As the multiplexer advances a step, the clock pulse also is used to dump or empty the clamp and allow the next input to fill the clamp. (The operation of the clamp circuitry was described and shown in Fig. 5-24 of the previous chapter.)

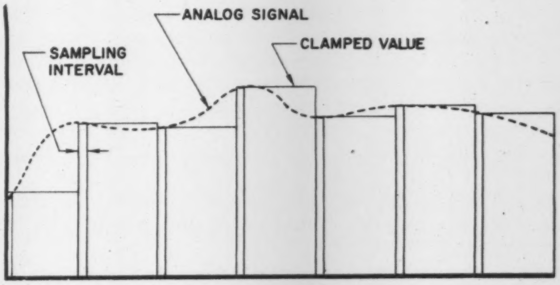


Fig. 6-14. A clamp is required to hold the value of the analog signal in the lengthy intervals between sampling.

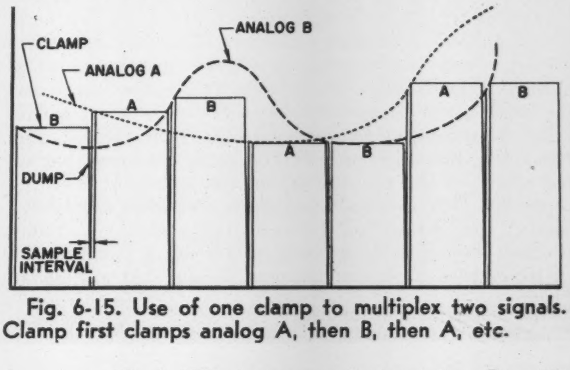


Fig. 6-15. Use of one clamp to multiplex two signals. Clamp first clamps analog A, then B, then A, etc.

RADAR and MTI

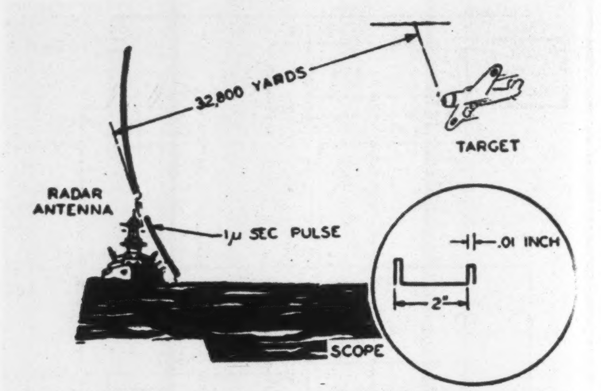


Fig. 1. Shipboard radar scope signal (Type A) at instant of echo reception from target at 32,800 yards when indicator sweep speed is 10 inches/millisecond.

An MTI (moving target indicator) radar is one equipped with special circuits so that only targets that are moving are presented on the indicator. Here is a review of the principles and elements of radar (radio detection and ranging) and the special MTI circuits. Of particular importance are the descriptions of tests performed and the instrumentation employed.

M. H. ARONSON*
S. I. SIXFIN**
G. O. THOGERSEN**

RADAR (Radio Detection and Ranging) is echo sounding by means of radio waves. A radar equipment directs a narrow beam of r-f energy over a region to be searched. When the beam strikes any object, a small amount of the energy is reradiated and returned to the radar set, which indicates the echo. The bearing or elevation of the object can be determined from the direction in which the radar antenna is pointed; the range of the object is determined from the time interval between the instant of energy transmission and the instant of echo reception (Fig. 1). As r-f energy travels at a velocity of 328 yards per microsecond (the speed of light), and as the r-f energy must travel from transmitter to target and back, the range (in yards) is equal to the time interval (in microseconds) between the instant of energy transmission and the instant of echo reception times 164.

There are two basic types of radar—*pulse* (in which a series of pulses is transmitted) and *continuous wave* (in which the transmitter operates continuously). Pulse radar was first used in 1924, by Breit and Tuve of the Carnegie Institute of Washington, to prove the existence of ionospheres. They used a series of pulses and measured the time interval between the transmission of a pulse and its reception as an echo. In England, at about the same time, Barnett and Appleton performed a distance measurement by transmitting an f-m signal and measuring the difference in frequency between that of the echo and the transmitter (at the instant of echo reception). This is *continuous-wave frequency-modulated radar.* The distinction between pulse and c-w radar becomes less clear in systems which use a combination of techniques. It is conventional to say that any radar set that transmits energy more than 10% of the time is a c-w radar, even though it is transmitting pulsed signals. (Most pulse radar sets transmit for less than 0.1% of the time between pulses.)

Pulse radar is most commonly employed because information is collected rapidly; c-w radar is used where other factors (such as ability to work to zero range and to reject clutter) are more important than rate of information collection.

Pulse Radar

Pulse radar uses a succession of short pulses of r-f energy. Depending on the use of the radar set (long-range search, short-range fire control, etc.), the frequency of the r-f transmission can be from 100 to 25,000 Mc, the pulse repetition frequency (PRF) can be from 100 to 4,000 pulses per second, the duration of each pulse can be from 0.1 to 10 microseconds. Note that the PRF establishes the maximum range measurable by the radar set—at maximum range, the time required for one pulse to travel to the target and return is the interval between pulses.

Distance measurement is made by measuring the time interval between transmission of a pulse and reception of its echo. This time interval is measured by using the sweep of a spot of a cathode-ray tube. The spot sweep is started at the instant that the r-f energy is transmitted; the spot is then either deflected or intensity modulated by the returning echo, depending on the type of indication.

As has been mentioned, the basic advantage of pulse radar, which has led to its common use, is the high rate at which information is collected. This advantage is not an unmixed blessing; when the radar "sees" too much, many unwanted echos (ground clutter, sea clutter, cloud echoes) interfere with recognition of the target. Although circuits have been developed to accentuate a strong echo relative to a background, these circuits can not operate when echoes from the target and the background are of the same order of magnitude. To cope with this problem resort is made to another technique known as Moving Target Indication (MTI).

---

*Instruments and Automation
**Airborne Instruments Laboratory, Inc.

Moving Target Indication (MTI)

MTI-equipped radar sets* differentiate between moving and fixed targets by precisely measuring the time required for a round trip of successive transmitted r-f pulses. The MTI circuits compare two *successive* pulses which are returned from the same target. If the target is stationary, the two pulses will be returned at precisely the same time after the instant of transmission. If the target is moving, any two successive pulses from the same target will return at slightly different times relative to the instant of transmission. This relative time difference, which is so small that it must be measured in terms of the change of phase of the r-f signal, can be detected by an MTI-equipped radar set and forms the basis of differentiation between fixed and moving targets.

The phase differences between successive returns are measured in a phase-detector circuit. The output of the phase detector is stored for one pulse period in a delay line and then is compared in a cancellation circuit with the (unstored) output resulting from the following pulse. If the target is fixed, the phase-detector output is unchanged and is cancelled. If the target is a moving one the phase detector output will change from pulse to pulse and the cancellation circuit will yield a signal which is then presented on the indicator.

As MTI can detect small moving targets in the presence of large fixed targets, it is particularly effective in the detection of aircraft under conditions of heavy ground clutter. This is important in the field of air defense and in the field of air traffic control.

The Radar and MTI System

A block diagram of a typical pulse radar is shown in Fig. 2 (the elements of a typical MTI-equipped system are shown in Fig. 5 for comparison). The basic differences are the addition of the coherent i-f oscillator, the phase detector and the cancellation unit in the MTI system, and the replacement of the radar local-oscillator with a highly stable local-oscillator especially designed for MTI use. The principles of these units will be described, along with the operation of each unit of the radar.

The same antenna is used for transmission and reception in both systems. The timer establishes the PRF and triggers the transmitter simultaneously with the beginning of the sweep in the indicator. The received echo signal appears on the indicator. The T-R (transmit-receive switch) is a gas tube that acts like a switch to (1) protect the sensitive receiver from the high-power pulse being delivered to the antenna from the transmitter and (2) keep the weak echo signal from losing energy to the transmitter when it is being delivered to the receiver, thus assuring that all its low power reaches the receiver.

Timer

The timer, or master oscillator, determines the PRF of the system. This oscillator times the start of both the indicator and transmitter. It often is a phase-shift oscillator, a self-blocking oscillator, a multivibrator, or the rotary mechanical motion of a spark-gap modulator. When many radars are in operation simultaneously, as on a ship, the master timing signals can be taken from the ship's master oscillator. This synchronizes all the radars and prevents interference between radars. When the ship's master oscillator is used, the timer oscillator in the radar set is turned off or bypassed.

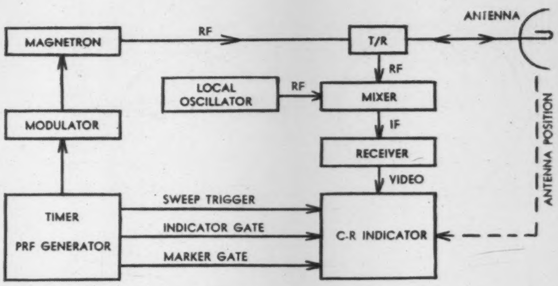


Fig. 2. Block diagram of a pulse radar system, showing all essential elements.

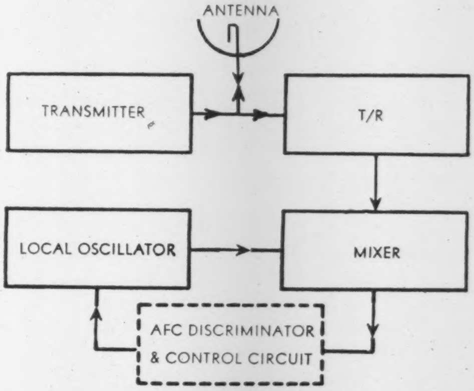


Fig. 3. Automatic frequency control (AFC) circuit which adjusts the local oscillator and which operates on the signal that leaks through the T/R tube when the transmitter fires. If the frequency of either the transmitter or local oscillator varies, the AFC circuit adjusts the local oscillator so that the i-f signal from the mixer is at the proper i-f frequency.

Transmitter

The transmitter consists of a high-power r-f oscillator that is keyed by a modulator (pulser). The high-power r-f oscillator is usually a magnetron, which produces the pulse of r-f energy. The peak power of the pulse is usually from 10-200 kw. The average power is much less because the pulse repetition frequency is less than 4000 per second, and the pulse length is less than 10 microseconds. The frequency of operation usually is between 100 and 25,000 Mc, depending on the type of radar.

Modulator

The modulator, or pulser, is the circuit that produces and shapes the pulse that keys the magnetron. It usually is a pulse-forming network (PFN), such as an artificial

---

*The discussion in this article is concerned with the "coherent" type of MTI.

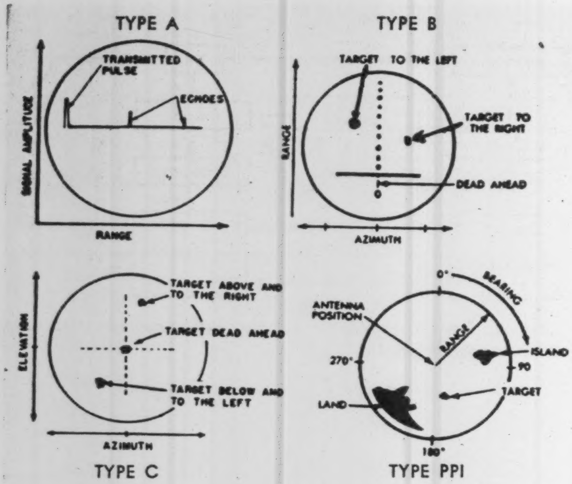


Fig. 4. Radar indicator types. Note that Type A shows range only; Type B gives range and azimuth data; Type C gives elevation and azimuth; type PPI gives range and bearing.

Table 1.—Methods of Radar Indication

Type	Range	Bearing	Elevation
A	x		
B	y	x	
PPI	r	θ	
E	x		y
RHI	x		y
C		x	y

line, that discharges through a thyratron switch. The PFN determines the duration of the r-f pulse. The thyratron usually controls a pulse transformer that drives the magnetron.

R-F Lines

The signal from the transmitter reaches the antenna through r-f lines—either coaxial lines or rectangular waveguides. As the antenna must be movable, rotary joints are required on the lines. These joints, called *choke joints*, use quarter-wave sections of line to prevent loss of r-f energy across open spaces in the choke joints.

T-R Switch

The T-R (transmit-receive switch) is a switch that breaks the circuit to the receiver when the transmitter operates. If this circuit were not broken, the sensitive crystals in the input circuit of the receiver would be burned out by the high-power r-f pulses. In addition, when the low-power echo signal is received, the T-R switch effectively breaks the circuit between antenna and transmitter so that the weak energy of the signal reaches the receiver. As no mechanical switch can operate at the PRF of the radar (100 to 4000 pulses per second), a gas tube is used as a switch.

Antenna System

The antenna system includes the radar antenna and its positioning system. In addition, special IFF (identification—friend or foe) antennas may be in the antenna circuit. Various types of antennas are used, depending on the radiation pattern desired. The shape of the pattern is dictated by tactical considerations—search radars have wide beams in order to cover a wide area; fire-control radars require narrow beams to "pinpoint" a target.

Receiver

Almost all modern radar receivers are superheterodyne. As r-f amplification is not practical above 1000 Mc, most radars have no r-f amplifier stages; the input circuit is a crystal mixer that mixes the local-oscillator signal and the echo signal to produce the i-f signal. The local oscillator is usually a Klystron, although some low-frequency radars (below 1000 Mc) use lighthouse-tube high-frequency triodes.

Most radars have an interesting automatic-frequency-control circuit (Fig. 3). If either the magnetron in the transmitter or the Klystron in the receiver drifts in frequency, the echo signal received will not be at the proper intermediate frequency after heterodyning, and the receiver gain will be low. To prevent this, the Klystron frequency is controlled by the AFC circuit shown in Fig. 3. When the transmitter fires, a small signal leaks through the T-R tube and into the mixer, which mixes the signal with the local-oscillator signal. If the heterodyned output frequency is not at the proper intermediate frequency, the discriminator in the AFC circuit adjusts the local oscillator which is made to operate at the correct frequency so that the echo signal is heterodyned exactly to the receiver intermediate frequency.

The mixer in Fig. 3 is a single crystal, which also is the first detector in the receiver. Most modern radars with AFC have a double-mixer input; one crystal is for mixing the echo signal with the local-oscillator signal, the other is for mixing the AFC signal (taken from an attenuator in the transmitter circuit) with the local-oscillator signal.

Following the mixer in the receiver are the i-f amplifier stages, the second (video) detector, the video amplifier, and the cathode-ray-tube indicator. These are conventional circuits. However, several specialized gain-control circuits such as AGC, DBB or STC may be utilized.

An *automatic gain control* (AGC) reduces the gain of the receiver when a strong signal is received. This prevents saturation blocking of i-f and video amplifier stages.

A *detector balance-bias circuit* (DBB) is a circuit that biases the video detector when a large signal is received. This increases target definition on the indicator.

A *sensitivity-time control circuit* (STC) reduces the gain of the receiver immediately after each pulse is transmitted and then permits the receiver gain to recover slowly. This reduces the sensitivity of the receiver to large sea returns and returns from nearby targets, preventing these large signals from saturating i-f stages and blocking the receiver. Note that these three circuits—AGC, DBB, and STC—are all gain-control circuits.

Another specialized receiver circuit is a *gating circuit*. This is an amplifier stage that is turned on for only a given interval during the interval between pulse transmissions. Only echoes from a given range can then pass through to the indicator. This permits "tracking" of a single target and is used commonly in fire-control radars.

Indicators

The radar indicator is a cathode-ray tube. There are many ways in which the echo can be presented on the face

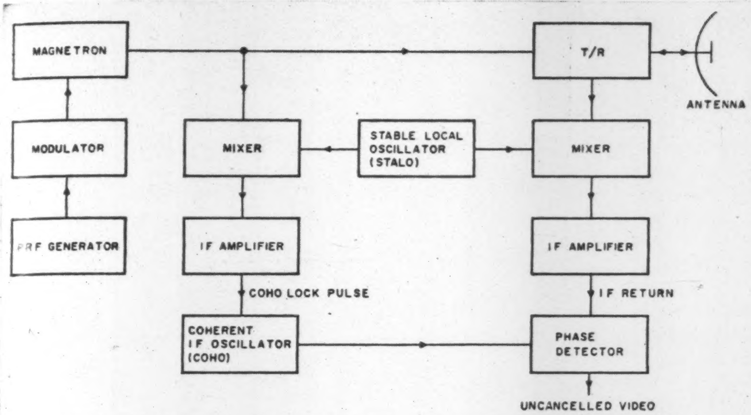


Fig. 5. Elements of an MTI radar—up to the uncancelled video output, which is fed to the cancellation units shown in Fig. 6.

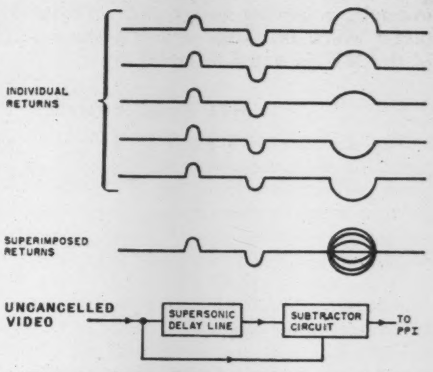


Fig. 6. Cancellation circuit, comprising delay line and subtraction circuit, subtracts each return from the previous return. This cancels out returns from stationary targets, leaving only the difference between the returns from moving targets.

o the tube to give range, bearing, and/or elevation of t rgets. In "Type A" indicators (Fig. 4), range is pres nted on the x coordinate, and the target is presented b deflection of the spot vertically; only range is measu ed. Range and bearing are measured in "Type B" and "ype PPI" (plan-position-indicator) presentations. In "ype B," range is presented in the y coordinate, beari g in the x coordinate. In "Type PPI,"[2] range is in the r c ordinate, bearing is in the θ coordinate. In "Type C" p esentation, bearing is given in x coordinates and elev tion of antenna in y coordinates. There are many modifi ations of these basic indication types. Table 1 shows the coordinates in which the data are presented. The RHI is a range-height indicator.

Principle of MTI

In a conventional coherent MTI system such as illust ated in Fig. 5, the r-f echo signals are superheterodyned t intermediate frequency, as is a sample of the outgoing t ansmitted pulse. The phase of the outgoing pulse is "remembered" by a coherent i-f oscillator (coho) which i locked in phase with the sample of the transmitted pulse. The superheterodyning is achieved with the use of a highly stable local oscillator (stalo). The i-f return s gnals are supplied to the MTI receiver, which includes a i-f amplifier and a phase detector. Since only phase is o interest in coherent MTI, amplitude variations are r moved from the i-f return signals by operating the i-f a nplifier as a limiter.

The amplified i-f return signals are then supplied to t e phase detector where they are compared with the c-w r ference signal from the coho. The amplitude of the outp t of the phase detector (which is known as uncancelled deo) is a measure of the phase of the echo signal using t e coho as a reference. As echoes from fixed targets h ve a constant phase relation to the transmitted pulse, t e phase detector output will be the same for successive lses, as shown at the top of Fig. 6. However, for movi g targets the phase detector output will vary from pulse t pulse. If the uncancelled video from a series of pulses ere presented on an A scope its appearance would be i lustrated by the pattern marked "superimposed ret rns" in Fig. 6.

By storing the uncancelled video for precisely one pulse riod and then comparing it in a cancellation circuit ith the uncancelled video from the next pulse period, it is possible to remove the fixed targets from the presentation, as shown at the bottom of Fig. 6. Fig. 7 shows the pulse-to-pulse cancellation of echoes as it would appear on an A scope; the only signals appearing after cancellation are those from moving targets; all others are cancelled out.

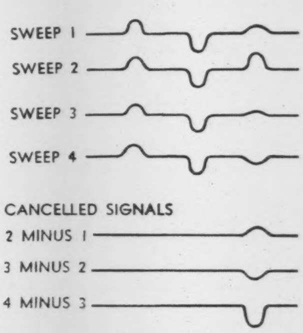


Fig. 7. Principle of pulse-to-pulse cancellation.

MTI Figures of Merit

Two criteria for judging the quality of an MTI are of sufficient interest to merit definition. These are *cancellation ratio* and *subclutter visibility*.

The *cancellation ratio* of an MTI is a measure of its ability to remove or cancel fixed targets. One of the imperfections in a practical MTI shows up in that the fixed targets are not completely removed; although they are strongly attenuated they may leave a small residue. The degree of attenuation is most easily measured by comparing the deflection resulting from the uncancelled portion of a fixed target with that from a much weaker moving target (not superimposed on the fixed target). If the deflections are equal, with the moving target 40 db weaker than the fixed target, one may say that the cancellation ratio is 40 db.

The *subclutter visibility* of an MTI is a measure of its ability to see a moving target superimposed upon a fixed target. An MTI which loses the moving target in the process of cancelling the fixed target is useless; the MTI must be able to see the moving target when it is directly superimposed upon the fixed target. The ratio of fixed to moving target at which the moving target can just barely be seen is called the subclutter visibility. If, for example, a moving target can be seen through a fixed target which is 30 db stronger, the subclutter visibility of the MTI is stated to be 30 db.

MTI Requirements

The designer of a good MTI imposes severe requirements on the components of the radar in order to secure good performance from his MTI. Some of the more important requirements concern *pulse time jitter, stalo stability, coho stability*, and the *characteristics of the i-f amplifier, phase detector, and cancellation circuits.*

If the time between successive pulses does not exactly match the delay in the storage portions of the cancellation circuits, the pairs of fixed target pulses presented for cancellation will not start and end simultaneously. To avoid such imperfect cancellation, the time jitter from pulse-to-pulse should be less than the pulse duration divided by the cancellation ratio. Thus, for an MTI-equipped radar set using 1-microsecond pulses and giving 40-db cancellation, the pulse time jitter must be less than 0.01 microsecond. Pulse-time-jitter trouble can occur in the PRF generator, the modulator, the magnetron, or the cancellation circuits.

If the stalo changes frequency during the round trip of the pulse—that is, between the time the coho lock pulse is generated and the time the fixed target echo returns—the fixed target will appear to be moving. Therefore, stringent requirements must be placed on the "short term" stability of the stalo. This means that frequency changes between successive pulses must be less than a few parts (in some cases one part) in 10^8. Much less stringent requirements are placed on the slow drift of the oscillator. It is clear that, if frequency is allowed to change one part in 10^8 per pulse period, drifts of one part in 10^5 per second are allowable—that is, drifts in the order of a few kc/sec are permissible.

The i-f amplifier must limit over a wide dynamic range. The phase detector should have as nearly as possible a linear relation between output and phase. The transient and amplitude responses of the two channels (delayed and undelayed) in the cancellation circuits must match very closely (within one percent to secure 40-db cancellation).

Most of the above requirements are difficult to measure with conventional test equipment. Consequently both for production inspection and for field use it is desirable to have available test equipment capable of making the necessary measurements in a substantially direct way.

Test of an MTI

Fig. 8 (and this month's cover) shows final production tests in progress on a Moving Target Indicator Group (MTI) at Airborne Instruments Laboratory, Mineola, N. Y. The equipment on the left in the picture is the MTI portion of Radar Set AN/FPS-8. Approximately 200 of these MTI's were designed and built by Airborne Instruments Laboratory for the General Electric Company, the prime contractor for the AN/FPS-8 Radar Set.

Quantitative testing of MTI's demands the utmost in test equipment precision. The assembly shown on the right is an equipment dolly containing the various types of instruments required to perform unit and system tests. The lower shelf contains a *Hewlett Packard Type 200C Audio Oscillator* and a *Measurements Corporation Type 80 r-f Signal Generator*. The middle shelf holds a *Measurements Corporation Type 79B Pulse Generator* and a *Hewlett Packard Type 212A Pulse Generator*. The top shelf supports a *Tektronix Type 511AD Oscilloscope*, a *Daven Type 640 Pushbutton Attenuator* and an *AIL Type AN/UPM-41 MTI Evaluator*. On top of the evaluator are two *Weston Type 455 Precision Voltmeters* and a *Hewlet Packard Type 410B Vacuum Tube Voltmeter*. These instruments all play an important role in the alignment an production test of the MTI equipment.

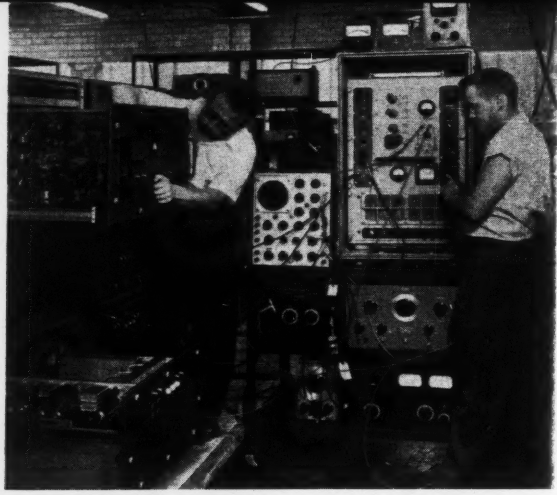


Fig. 8. Testing an MTI at AIL. Tests performed an equipment used are discussed in article.

Tests Performed

Several tests are performed, including (1) an *alignment and gain bandwidth measurement* on the 9-Mc dua channel carrier system (using the Measurements Mode 80 Signal Generator as a carrier source with the HI Model 200C Audio Oscillator providing the carrier mod ulation; (2) a *video cancellation ratio measuremen* (using the Measurements Type 79B Pulse Generator t simulate fixed target signals, the Hewlett Packard Typ 212A Pulse generator to simulate moving targets, and th Daven Type 640 Attenuator to indicate the video cancellation ratio in db); (3) *initial voltage checks* and adjustments using the Weston Type 455 precision meters Hewlett Packard Type 410B Vacuum Tube Voltmete and Tektronix Type 511AD Oscilloscope; (4) a *stal stability test* utilizing an AIL Type 392A Stalo Stabilit Tester; (5) MTI performance checks such as a *puls jitter test*, a *coho stability test* and a *subclutter visibilit measurement* using the AN/UPM-41 MTI Evaluator.

MTI Evaluator

The AIL Type AN/UPM-41 MTI Evaluator permit measurement of MTI performance factors such as subclutter visibility, cancellation ratio, coherent oscillato stability, and target velocity response of the phase detector. A separate oscilloscope section permits observation of trigger pulse jitter to values as small as 0.0 microsecond.

The MTI Evaluator generates simulated i-f signal corresponding to those normally received by the MT from the radar. Separate moving and fixed target signal are provided, both being adjustable in range and the moving target being adjustable in radial velocity as well. Th two simulated target signals are passed through ind vidually adjustable attenuators, and then are mixed fo presentation to the MTI.

For further details on the theory and operation of th AIL type AN/UPM-41 MTI Evaluator, reference shoul be made to the article "An MTI Evaluator" by J. R. Wilkerson, Proceedings of the National Electronics Confe ence, Volume 10, page 428, published February 195 More than 770 MTI Evaluators were designed and produced by AIL for the USAF Gentile Air Force Depot.

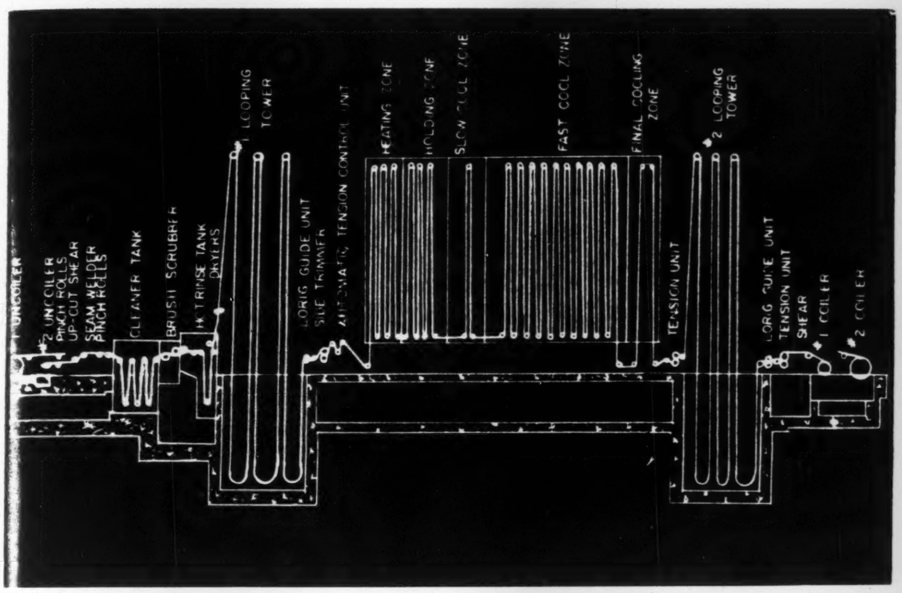

#1 UNCOILER
#2 UNCOILER
PINCH ROLLS
UP-CUT SHEAR
SEAM WELDER
PINCH ROLLS
CLEANER TANK
BRUSH SCRUBBER
HOT RINSE TANK
DRYERS
#1 LOOPING TOWER
LORIG GUIDE UNIT
SIDE TRIMMER
AUTOMATIC TENSION CONTROL UNIT
HEATING ZONE
HOLDING ZONE
SLOW COOL ZONE
FAST COOL ZONE
FINAL COOLING ZONE
#2 LOOPING TOWER
TENSION UNIT
LORIG GUIDE UNIT
TENSION UNIT
SHEAR
#1 COILER
#2 COILER

Fig. 1. Continuous strip anneal line has 3000 feet of strip in the uncoiling, furnace, and recoiling zones.

Continuous-Anneal-Line Control

Instrumentation makes possible the operation of a continuous anneal line handling a 3000-ft strip traveling at 1000 ft/min. The system includes gas distribution to the various furnace zones, gas flow measurement, recording of O_2 and combustibles, control of various furnace zones, and control of water supply for cooling jackets.

J. E. WEBBER, U. S. Steel Corp., Fairless Works

CONTINUOUS ANNEAL LINE at Fairless Works has an estimated capacity of 30 tons/hour, attained by the flow of a 30-inch-wide strip, 0.010-inch thick, t a speed of 1000 feet/minute.

Control by instruments on this line is the major factor the assurance of prime product.

The Line

The line functions as a single continuous unit, with a rip pass line 3,000-feet long. For descriptive purposes e line can be considered as consisting of three zones: he uncoiling, the furnace, and the recoiling zones, as own in Fig. 1.

Ram trucks bring coils to the line from the cold mills. They are uncoiled in the uncoiling zone. There is little instrumentation in this zone. The strip progresses through roll, shears, welder, electrolytic cleaner, and tension bridle to the furnace.

The furnace zone comprises entry and exit *looping towers, tension bridles, side trimmer,* and the *furnace,* which uses a combination of gas and electric annealing. Most of the instrumentation is found here.

The third, or recoiling, zone consists of a bridle assembly, shear, and winding reels. The coils are hydraulically stripped from each reel onto a coil car. There is no instrumentation in this zone.

Uncoiling Zone

Strip to be processed, when received, is coated with the rolling solution. Cleaning baths remove this solution.

---

resented at Conference on Instrumentation for the Iron & Steel Instry, Pittsburgh, 1955.

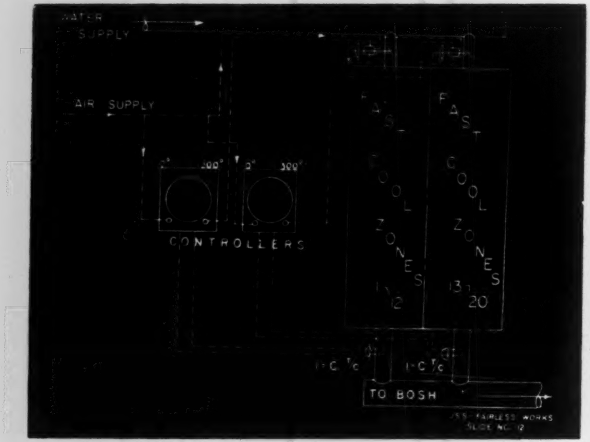

WATER SUPPLY
AIR SUPPLY
0° 300°
0° 300°
CONTROLLERS
FAST COOL ZONES 1-12
FAST COOL ZONES 13-20
I-C T/c
I-C T/c
TO BOSH
USS FAIRLESS WORKS
SLIDE NO. 12

Fig. 4. Control system for the water supply to the jackets of the fast-cool zone is required because excess cooling would buckle the light-gage strip.

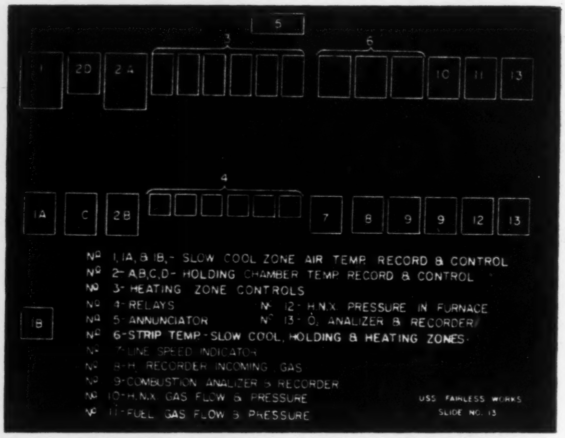

5
3
6
1
2D
2A
10
11
13
4
1A
C
2B
7
8
9
9
12
13
1B
Nº 1, 1A, & 1B,- SLOW COOL ZONE AIR TEMP. RECORD & CONTROL
Nº 2- A,B,C,D- HOLDING CHAMBER TEMP. RECORD & CONTROL
Nº 3- HEATING ZONE CONTROLS
Nº 4- RELAYS
Nº 5- ANNUNCIATOR
Nº 6-STRIP TEMP.-SLOW COOL, HOLDING & HEATING ZONES
Nº 7-LINE SPEED INDICATOR
Nº 8-H. RECORDER INCOMING GAS
Nº 9-COMBUSTION ANALIZER & RECORDER
Nº 10-H.N.X. GAS FLOW & PRESSURE
Nº 11-FUEL GAS FLOW & PRESSURE
Nº 12- H.N.X. PRESSURE IN FURNACE
Nº 13- O₂ ANALIZER & RECORDER
USS FAIRLESS WORKS
SLIDE NO. 13

Fig. 5. Master control panel: HNX and fuel-gas instruments are grouped at right (8-13); three strip temperature recorders are next (6); other instruments are indicated.

Holding Zone

The holding zone with its 6 vertical stands provides a soaking section of 300-foot length. Ribbon-type electric heating elements suspended on the four side walls by either refractory or alloy-steel hangers provide the heat.

For control purposes, the holding zone is divided into 4 distinct sections. These sections are operated from 4 controllers of 0-2000° F temperature range. Zone #1 has a recording controller; the other three have indicating controllers. Zone #1 receives its impulse from a radiation head located at the discharge end of the slow-cool zone. The other three instruments are actuated by iron-constantan thermocouples located in the sidewalls of their respective zones.

Slow-cool Zone

Strip temperatures in the two vertical stands of the slow-cool zone are controlled by a series of air-cooling tube which are mounted horizontally in the zone so that each strand of strip passes between a cooling-tube bank.

The slow-cool zone has an air-temperature recorder and two controllers. The recorder has a range of 700-1400° F and reads air temperature sensed by a radiation head mounted in the outlet of the slow-cool zone.

The controllers are both actuated by iron-constantan thermocouples of 0-2000° range, and maintain temperature by throttling butterfly valves in the air blower outlets, one for zone #1 and one for zone #2.

Fast-cool Zone

The function of the final furnace section, the fast-cool zone, is to reduce the temperature of the strip under controlled atmospheric conditions to such a level that the strip can be exposed to normal room air without the formation of undesirable surface oxides. This is accomplished by the travel of the strip between 20 individually-water-jacketed vertical chambers, which afford a continuous pass line of 1000 feet.

The water supply for the jackets must be controlle (Fig. 4). Unrestricted flow would permit excess coolin and thereby create buckling of the light-gage strip. Temperature control is provided by two controllers, one fo zones 1-12 and the other for zones 13-20. The controllers actuated by iron-constantan thermocouples in the outle water lines, have 0-300° F range and supply 3-15-psi output air signals which operate control valves in th water line. Normal temperature of zones 1-12 is 180° F and of zones 13-20 is 125° F. There is also a filled-system-type indicating thermometer showing temperature o incoming water, which has an average temperature o about 65° F. In addition to the above, there is a bellows type indicating flowmeter showing the rate of total wate flow. It has a range of 0-1550 gpm, and the operating flo is about 600 gpm.

Master Control Panel

Fig. 5 shows the layout of the master control panel. Th six HNX and fuel-gas instruments are grouped on th right-hand side of the board. There are three recorder for strip temperature. The first is an 800-1800° F-rang single-point instrument recording the temperature of th strip as it leaves the holding zone (normal is 1100° F) The second (recording strip temperature leaving the slow cool zone) is a 500-1000° F-range instrument operatin from a radiation head (normal is around 850° F).

Next to this group are the heating-zone control instruments. The other zones follow in sequence, with the fas cool panel facing the master panel so that the operato can observe all controls from a central position. Th other instrument on the master panel is a convention line-speed indicator calibrated in feet/minute.

It is the feeling of the operators and the instrume group that the controls for this line have proved succes ful from the standpoint of ease of operation, satisfactor control of metallurgical characteristics of product, an maintenance.

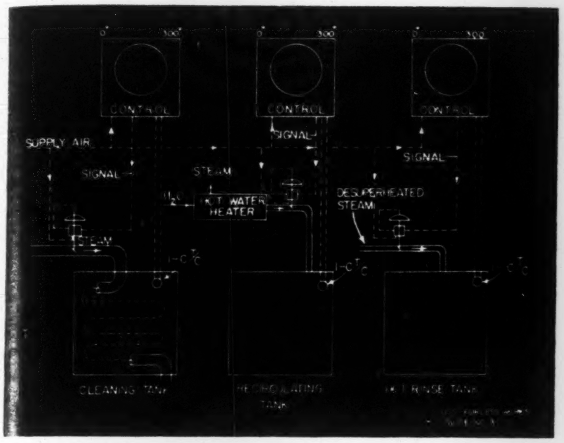


Fig. 2. Before strip enters furnace, the rolling solution must be removed in the cleaning bath, which comprises cleaning tank, recirculating tank, and hot-rinse tank. The temperature in each tank is controlled by a separate controller with range of 0-300° F.

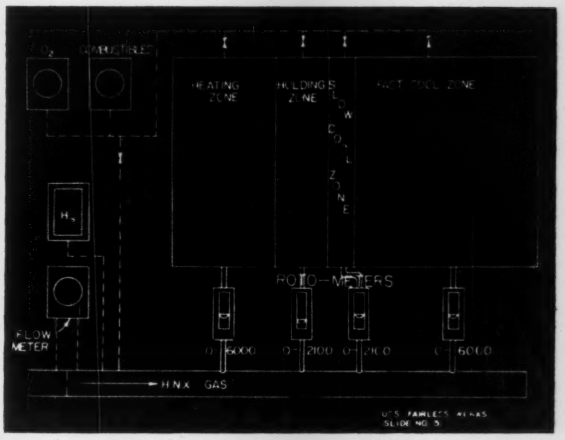


Fig. 3. The furnace has heating, holding, slow-cool and fast-cool zones. Gas flow to each zone is measured by rotameter-type flowmeters; O_2 and combustibles are recorded.

Temperature in the cleaner system is controlled by three electronic-type instruments actuated by iron-constantan thermocouples (Fig. 2). All three have a temperature range of 0-300° F. The single-seated steam-flow diaphragm control valves are actuated from an air output signal of the usual 3-15-psig range, and are located on the condensate side of the steam coils in the cleaner and recirculating tanks.

Furnace

The furnace proper can be subdivided into heating, holding, slow-cooling and fast-cooling zones, all of which must be operated as a gastight unit (Fig. 3).

HNX atmospheric gas is used for heating. It is supplied from a main generating station, and total flow is measured by means of an orifice-type recording flowmeter located on the main control panel.

Distribution of the gas to the various furnace zones is controlled by means of flow control valves, and indicated by rotameter-type flowmeters. The gas is distributed in the following manner: Heating zone—0-6000 cfh; holding zone—0-2100 cfh; slow-cool zone—0-2100 cfh; fast-cool zone—0-6000 cfh. Maximum capacity of the HNX gas generator is 30,000 cfh, and normal consumption is in the range of 14,000 cfh. Pressure in the bottom of the furnace is 0.5-inch water column.

Records are taken of O_2 and combustibles. The instruments are manifolded so that the gas can be sampled at any one of six points in the furnace or in the incoming line. H_2 in the incoming gas line also is recorded.

Heating Zone

The heating zone contains six passes. Heat is provided by 107 evenly-spaced radiant tubes, each having a burner rating of 225,000 BTU/hour. Incoming air is preheated by the exhaust gases and the radiant tubes operate under a partial vacuum. The incoming natural gas, with a heating value of 1060 BTU/cu ft is delivered to the control valve at approximately 15 psig, where it is reduced to 3 psig for use in the main burners.

Control of the reducing valve was extremely difficult because the starting and stopping of the line necessitated an almost instantaneous response. The problem was solved by the use of an air relay to magnify the deviation from the set point and thereby speed up the response of the valve. Gas flow rate is measured by means of a conventional orifice meter operating on the furnace side of the valve.

Ignition of the main burners is accomplished by a premix system, with a constant pilot having its own air blower and a natural gas supply reduced from 15 psig to 5 psig. In order to maintain a constant fuel/air pressure ratio to the mixing valve, the gas is throttled by a control actuated from the supply air pressure. The 3-psig main fuel supply then goes to a battery of 6 control valves operated by control drives, each of which regulates fuel to one of the zones or battery of 18 radiant tubes.

As the control of each of the 6 zones is identical, only one will be described. The primary control element is a radiation head sighting the end of a radiant-tube firing leg. The millivolt signal is conducted to an electronic controller-recorder. The controller operates an electric-motor drive linked to a butterfly valve on the discharge of a blower, the latter supplying the jet effect and maintaining a vacuum on the tubes and the combustion system. As the set point is reached, the butterfly valve throttles the ejector air, whereby the suction is relieved and the gas flow from the control valve is reduced. As the flow decreases, the gas pressure increases and an impulse is created and transmitted, which causes the drive motor to close the valve in the gas line. Although it is essentially an on-off control system, the lag in the system plus the effect of vacuum from a common flue, results in a partially modulated system.

The vacuum system which controls the gas flow to the burner, also controls the flow of combustion air. Combustion air enters the burner through a tube around the heating-element exhaust leg, thus preheating the combustion air.

Fig. 1. Digital ohmmeter makes possible fast and accurate production testing of precision resistors.

The Digital

Digital readout is the "new look" in voltmeters, ohmmeters, and other test instruments. Meet the digital ohmmeter. Here is the story behind its development, including some interesting Wheatstone-bridge fundamentals.

C. P. DeWITT
Electro Instruments, Inc.

INCREASED use of precision resistors has posed a problem throughout the electronics industry. The conventional Wheatstone bridge provides an accurate instrument for measuring the resistors, but it is limited in three respects—(1) its operator must be skilled in its use in order to select proper ratio, bridge voltage, and galvanometer damping to obtain maximum accuracy, (2) an error in operation can burn out the galvanometer or overheat a bridge resistor, and (3) the hand operations required to balance the bridge make it too time consuming to be a production tool for rapid measurement.

The digital ohmmeter (Fig. 1) was designed to overcome these three problems of operator training, instrument delicacy, and speed of measurement. This instrument combines the accuracy and dependability of the precision Wheatstone bridge with a completely automatic measuring system. It automatically selects the proper bridge ratio for maximum accuracy, automatically balances the bridge through a sensitive null detector, and automatically presents the value of the unknown resistor in illuminated numerals in the in-line digital readout. Average time per reading is 1 second; even higher speeds are possible when checking resistors of the same nominal value.

Basic Factors in Wheatstone Bridge Use

The major sources of error in a Wheatstone bridge are (1) discrepancies between the true and the marked value of the rheostat and of the ratio of the ratio arms, (2) inaccuracy of the balance point due to insufficient sensitivity of the balance detector, (3) changes of resistance due to self-heating of one or more of the resistors in the bridge, (4) thermal EMF's in the bridge or null-detector circuit, and (5) personal errors in finding the balance point, in taking the readings, and in making computations.

Factors 1, 3, and 4 are functions of manufacturing technique; the bridge in the digital ohmmeter is constructed to the rigorous specifications common to all precision Wheatstone bridges. For example, the power dissipated in the bridge resistors of the digital ohmmeter is limited so that the self-heating effect never exceeds 2 Centigrade degrees, all materials and connections are selected for low thermal EMF's, etc. Factor 5 is eliminated as a source of error in the digital ohmmeter because of the automatic balancing feature. Factor 2, the sensitivity factor, warrants detailed discussion.

Sensitivity of a Conventional Bridge

Fig. 3 shows a conventional bridge (left) and the digital-ohmmeter bridge, both measuring a 500,000-ohm resistor that is actually 500,050 ohms. Both bridges are thus unbalanced by 0.01%. Note that the digital-ohmmeter bridge uses a 100-volt source rather than a 5-volt source. (Conventional Wheatstone bridges use a source of between 1.5 and 50 volts.)

The galvanometer current (i) in the conventional bridge equals the open-circuit voltage divided by the ou-

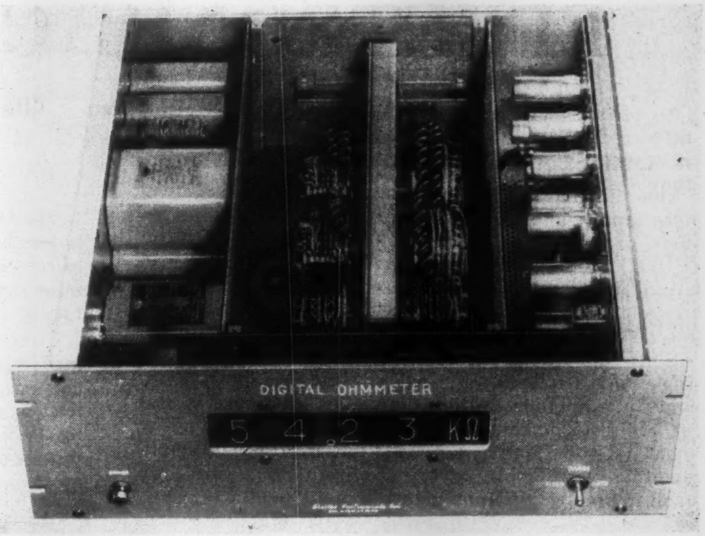


Fig. 2. Close-up view shows automatically stepped switches for selecting proper range ratio and for controlling the rheostat arm of the bridge.

Ohmmeter

ut resistance of the bridge. The open-circuit voltage E_g) is:

$$E_g = 5\,(100/5100 - 10{,}000/510{,}050) = 9.6 \text{ microvolts.}$$

The output resistance of the bridge (R) is:

$$R = (100)(5000)/5100 + (500{,}050)(10^4)/510{,}050 = 9898 \text{ ohms}$$

Therefore, the galvo current is:

$$i = 9.6/9898 = 0.009 \text{ microamp}$$

This will cause about 0.2 mm deflection of a typical 20 mm/uamp galvanometer.

Sensitivity of Digital-Ohmmeter Bridge

Referring to Fig. 3, the open-circuit voltage of the ohmmeter bridge is

$$E_g = 100\,(100{,}000/150{,}000 - 1{,}000{,}000/1{,}500{,}050) = 2.22 \text{ millivolts}$$

The null detector used in the automatic bridge has 1-illivolt sensitivity. Hence the 2.22 mv unbalance in the bridge corresponds to more than 2 *digits unbalance* on he ohmmeter, a resolution of 2 parts in 500,000, or 0.0004%.

The chopper-type null-detector amplifier has an input mpedance of more than 1000 megohms; hence the higher mpedances of the digital-ohmmeter bridge do not decrease the null sensitivity (as they would in a conventional bridge).

Features of the Digital Ohmmeter

The digital ohmmeter shown in Fig. 2 has a useful range from 10.0 ohms to 10.000 megohms; it is capable of accuracies as high as 0.01% in the range from 1000.0 to 100K ohms. The null detector consists of a high-gain chopper amplifier, and has a sensitivity of 1 mv and an input impedance of 1000 megohms. The bridge, excited by a 100-v source, yields 0.001% resolution on each of its five ranges.

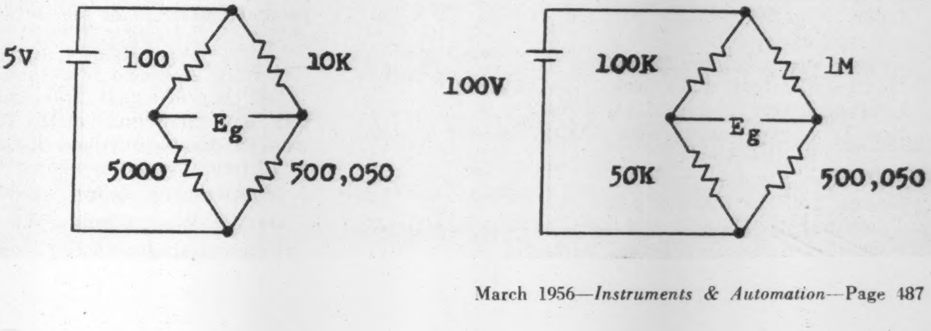
The pulse output of the chopper amplifier is phase detected and used to trigger one of two thyratrons. The "up pulse" thyratron causes a stepping switch to increase the resistance in the rheostat arm of the bridge; the "down pulse" thyratron steps switches in accordance with a logical pattern to decrease the rheostat arm.

The resistors of the ratio arm also are mounted on a stepping switch and the proper range ratio is selected in a similar automatic manner.

As the bridge is a full bridge, and not a comparison bridge, no external standards are needed for comparative measurements. It is of interest to note that where accuracies of 0.1% or better are needed, it is difficult to obtain a standard more accurate or stable than the resistor under test.

By means of test jigs, testing rates of 1000 resistors or more per hour are possible; an automatic printer can be added if a printed record is desired.

Fig. 3. Comparison of conventional Wheatstone bridge (left) and digital-ohmmeter bridge (right) for measurement of a resistance with value of 500,050 ohms.



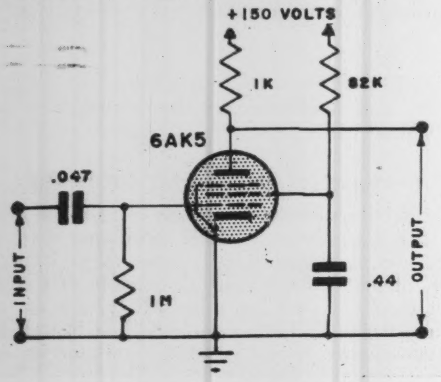
ELECTRONIC CIRCUITRY

MILTON H. ARONSON and **CHARLES F. KEZER**

LIMITER-AMPLIFIER FOR PULSE INPUTS

This circuit amplifies, limits, and inverts negative-pulse input signals. It is said to be proven by over ten years of field use, and is available in module form (P1001) from supplier. It is similar to NBS-BuAer Preferred Circuit PC21, and has been used as a video limiter between video detector PC20 and low-level cathode follower PC22 (see next circuit).

Since the circuit accepts only negative inputs, the single 6AK5 tube is operated at zero grid bias. Input pulses of amplitudes greater than 2.0 volts (peak) almost cut off plate current. Output thus remains constant at about 4.2 volts (peak) for input pulses larger in amplitude than the 2.0-volt limiting level. For input pulses too small to produce limiting, gain is 3.5.



Rise time and fall time of output pulses (with cathode-follower load, as described) is 0.035 usec, indicating that the circuit should be usable with pulses as short as 0.1 usec. For long pulses, input rise time is little changed, but the flat top of the pulse may be distorted by discharging of coupling and bypass capacitors during the pulse. This sag in the pulse top is sometimes called "droop" and is often expressed as a percentage of pulse amplitude. Droop is 3.5% for a 500-usec pulse; it is 3.5% for 100-usec pulses if grid capacitor is reduced to 0.01 uf and screen bypass to 0.1 uf.

Rise and fall times depend on the effective input and output capacitances, the latter including input capacitance of the load.

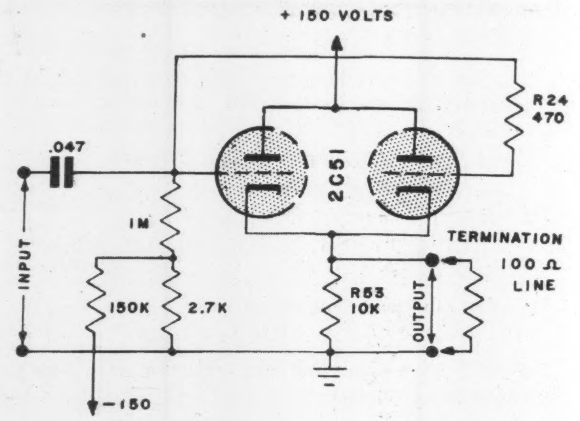
Rise time is determined with output delivered to a 2C51 cathode follower as follows: Resistive load is negligible; capacitive load is 16.15 uuf—made up of 6AK5 output capacitance (3.25 uuf), 2C51 input capacitance (5.9 uuf), sockets (2.0 uuf), and wiring (5.0 uuf). Rise time (t_r) = 2.2 RC, where C = 16.15 uuf and R = 1000 ohms; hence rise time = 0.035 usec.

Input: Negative pulses; should exceed 2.0 v for limiting.
Gain of stage: 3.5 for inputs less than 1.0 v pk.
Maximum Output: 4.2 v peak (positive pulses)
Limiting Level: 2.0 v peak input pulse.
Rise Time: 0.035 usec (with cathode-follower load as described).
Fall Time: Same as rise time.
Droop: 3.5% for 500-usec pulse.
Power Supply: 150 v dc at 4.8 ma; 6.3 v ac at 175 ma.
Source: Aerovox Corporation, Arlington, Va.

CATHODE FOLLOWER FOR LOW-LEVEL PULSES

The two sections of a 2C51 dual-triode are connected in parallel in this circuit to provide an output impedance of 100 ohms. Circuit is available in module form (P1002) from supplier. Circuit is similar to NBS-BuAer Preferred Circuit PC22.

Circuit operates into an externally connected 100-ohm load; load may be connected to the circuit via a coaxial cable or line of 100-ohm characteristic impedance. As the load is connected directly across the 10K cathode resistor (which could have been omitted), fixed negative grid bias is used to obtain the desired plate-current operating point. The voltage divider across the −150 v supply applies 2.7-volts negative bias to the grids; an additional 2.2 v of bias is obtained by the 22 ma of plate current flow in the 100-ohm load in parallel with R53.



Resistor R24 protects against parasitic oscillations that sometimes occur when tubes are parallel connected.

Circuit operates on positive pulse inputs; normal operating level is 1.0 v output for 2.2 v (peak) input. Maximum levels are 4.2 v input and 2.0 v output.

The 2C51 twin triode is made by Red Bank Div., Bendix Aviation Corp., Eatontown, N. J., which also make a 6385 replacement for the 2C51. Another replacement is the 5670 (which is directly interchangeable), made by General Electric, Raytheon, Sylvania, and CBS-Hytron.

Rise time is determined from $t_r = 2.2$ RC, where R = ohms and C = 9.1 uuf, comprised of the output capacitance of the 2C51 plus socket and wiring capacitance.

Hence $t_r = 0.002$ usec.

Fall time of signals from cathode followers is a function of the amplitude of the step function for large signals (in excess of about 1 volt), and can be as great as 10 times the positive-going rise time.

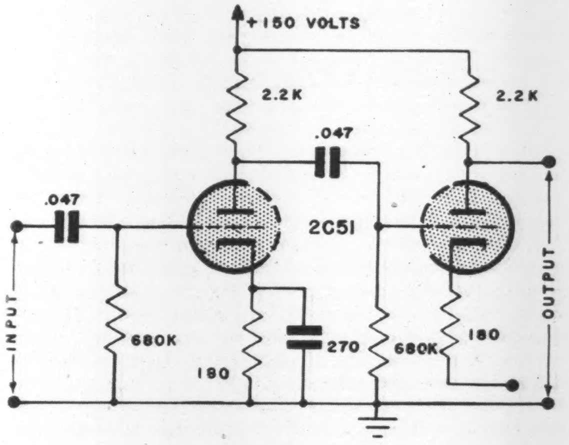
Input: Positive pulses, up to 4.2 v peak.
Output: Positive pulses, 2.0 v peak maximum.
Output Impedance: 100 ohms

Gain: 0.46 into 100-ohm load.
Rise Time: 0.002 usec.
Fall Time: depends on signal amplitude, as described.
Droop: 1% for 500-usec pulse.
Power Supply: +150 v dc at 22 ma; — 150 v dc at 1 ma; 6.3 v ac at 300 ma.
Source: Aerovox Corp., Arlington, Va.

TWO-STAGE VIDEO AMPLIFIER

Principal applications of this pulse-type amplifier are in radar and related circuitry. Circuit uses a single 2C51 miniature dual triode; it is available in module form (P1004) from supplier. (See previous circuit for details on 2C51.) Circuit is similar to NBS-BuAer Preferred Circuit PC26, used to amplify radar video signals.

Plate resistor values are kept low (2.2K) in this circuit to obtain fast rise time of the output pulses, as in other video circuits. Circuit accepts either positive or negative input pulses having amplitudes up to 0.5 v. Cathode resistor (180 ohms) of the second stage is normally returned to ground by an external connection. If gain control is desired, however, a 500-ohm variable resistor may be connected between the lower end of this resistor and ground to obtain gain control over a 4:1 range.



Rise time of output pulse equals the square root of the sum of the rise times of the two stages. Rise time of first stage (with cathode bypass capacitor omitted) is $t_r = 2.2RC = 0.092$ usec ($R = 2.2K$ and $C = 19$ uuf). The cathode capacitor, however, increases the gain at high frequencies and improves t_r by a factor of 2, to 0.046 usec. Rise time of stage 2 is 0.131 usec; it is larger than t_{r1} because (1) it has no cathode bypass and (2) effective capacitance at plate is higher (27 uuf) as it includes 19-uuf input capacity allowed for input capacity of driver shown in next circuit. Thus total t_r is:

$$t_r = \sqrt{t_{r1}^2 + t_{r2}^2} = \sqrt{0.0046^2 + 0.131^2}$$
$$= 0.139 \text{ usec.}$$

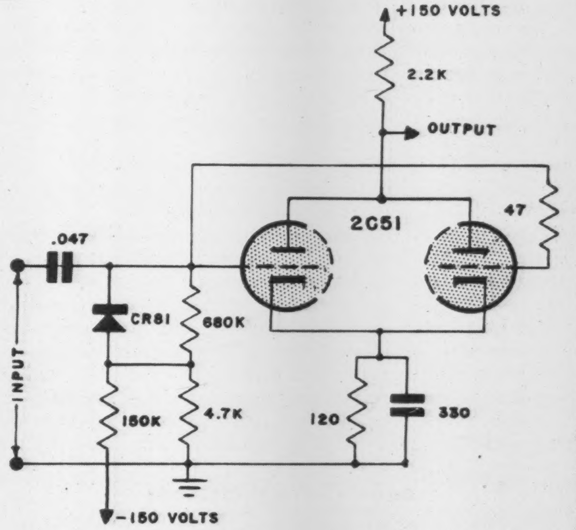
Input: Positive or negative pulses, up to 0.5 v peak.
Output: Up to 16 v peak.
Gain: stage 1—5.5; stage 2—5.5; over-all—30.25
Input Capacity: 11 uuf.
Output Capacity: 22 uuf (including 19-uuf input capacity of triode driver such as next circuit).
Rise Time: 0.14 usec (working into triode driver).
Fall Time: Same as rise time.
Droop: 1.5% for 500-usec pulse.
Power Supply: 150 v dc at 15 ma; 6.3 v ac at 300 ma.
Source: Aerovox Corp., Arlington, Va.

TRIODE VIDEO DRIVER

This video stage is used to drive the cathode of a cathode-ray tube to intensity-modulate the electron beam. It has been thoroughly proven in military use and is available in module form (P1005) from supplier. Circuit is similar to NBS-BuAer Preferred Circuit PC27.

Such a driver must supply negative output pulses to the CRT cathode (negative cathode voltage corresponds to higher beam current and an intensified spot). At least 60 volts of swing are required to provide proper blanking and intensification; this circuit provides an 83-volt swing which allows adequate margin for tube and circuit performance.

Crystal diode CR81 (1N70) provides d-c restoration, bringing the d-c grid potential always to the same value (—4.7 v) between input pulses. If d-c restoration were not provided, the charge on 0.047-uf input capacitor (and hence the average potential of the grids) would shift with the frequency of the input pulses and with their duration.



Resistor in grid of right-hand stage (47 ohms) is used to avoid paristic oscillations which tend to occur when tubes are connected in parallel. Rise time t_r (with 330-uuf cathode capacitor disconnected) = 2.2 RC where R = 2200 ohms and C = 20 uuf (comprised of output capacity of 2C51—2uuf; input capacity of CR tube—5 uuf; wiring and sockets—13 uuf). Hence $t_r = 0.097$ usec. This is improved by a factor of 2 by the cathode compensation capacitor, giving $t_r = 0.05$ usec.

Input: Positive pulses, up to 15 v peak.
Output: Negative pulses, up to 83 v peak.
Gain: 6.2.
Input Capacity: 19 uuf.
Rise Time: 0.05 usec (with 5-uuf capacitive load as described).
Fall Time: Same as rise time.
Droop: 1.5% for 500-usec pulses (measured with CR81 disconnected).
Power Supply: +150 v dc at 1 ma (no signal); —150 v dc at 1 ma; 6.3 v ac at 300 ma.
Source: Aerovox Corp., Arlington, Va.

CONTROL VALVES—No. 3

Basic Valve Types and Flow

The flow characteristic of a valve establishes its control action in service. Here is a thorough analysis of the characteristics of available valves, and a discussion of available valve types—quick-opening, piston, plug cocks, streamlined, rubber pinch, Saunders Patent, rubber sleeve, butterfly, angle, rotary piston, rotary disc, slide, remote manual loading, ball and seat, and low-flow control valves.

A CONTROL valve controls flow by opening and closing a port in the flow line. The relation between flow and valve motion can be altered by shaping the port or plug attached to the valve stem, thereby making possible different modes of control. This relation between flow and lift of the valve stem is called the *flow characteristic*, and can be expressed as a curve of flow vs lift, as shown in Figs. 3-1 and 3-2.

The flow is usually plotted as percent of maximum flow, and the lift as percent of maximum lift.

The curves show that valves are available with a wide variety of flow characteristics. Some valve bodies are constructed so that the flow characteristic can be varied by altering the shape of the plugs or pistons used as inner-valve trim. (Although only the body and inner valve are considered in this discussion of flow characteristic, correct selection requires consideration of the actuating mechanism or topworks, and the means of measuring the variable to be controlled, as will be discussed later in this series.)

Basic Plotting Methods

The flow characteristic is an important control factor, and it is therefore important that the method of plotting the characteristic curve be well understood. The characteristic curve is a plot of flow vs valve lift under the condition of constant 1-psi drop across the valve. The flow at each increment of lift is determined in the same way that C_v (maximum capacity) is measured.

The recommended procedure for obtaining C_v is t measure the water flow (for a given time interval) wit between 5- and 10-psi drop across the valve, and then t convert to flow at 1-psi drop by dividing by the squar root of the measured pressure drop.

As this characteristic is measured with constant pressure drop, it is not the actual flow characteristic realize in operation (which varies with different piping arrangements, operating conditions, etc.). What actually doe happen when the valve is in operation has been the subject of many papers, and the change in characteristic ha been found to depend on the relation between the pressur drop across the valve and all other drops in the system It is customary to stipulate that at least 1/3 of the tota pressure drop of a system must occur across the valve t restrict the deviation of the operating characteristic fro the given flow characteristic.

The two basic methods of plotting flow characteristic are shown in Figs. 3-1 and 3-2; each has advantages fo analyzing flow behavior. The first uses uniform coordinates with flow (percent of maximum flow) as the abscissa and percent of stem travel (or plug movement) a the ordinate.

The actual lift or plug movement in inches could b used as the ordinate to give a realistic picture for on particular valve. However, the comparison of data for tw valves may become confusing when using this approac because ¼-inch travel may give 90% of full flow for on valve, but only 12% for another style. The use of actua

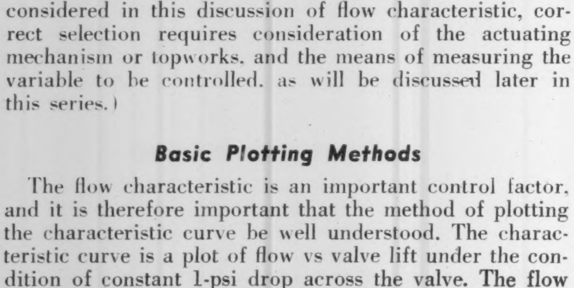


Fig. 3-1. Valve characteristic curves are plots of flow vs lift. These curves show linear and percentage characteristics as they appear on uniform coordinates. Curves are made under the condition of constant 1-psi pressure drop across valve—and thus are essentially curves of C_v vs lift, rather than true operational characteristics.

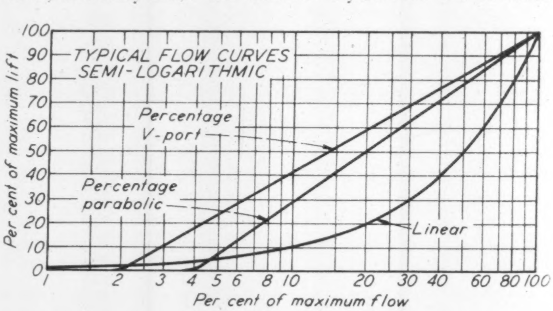


Fig. 3-2. Appearance of the flow characteristic curve of Fig. 3-1 when plotted on semi-log coordinates (flo scale is logarithmic). Advantage of logarithmic scale i that flow appears with equal percentage accuracy at lo end of scale as at high end.

Characteristics

C. S. BEARD
Foster Engineering Company

stem travel is, nevertheless, important for analyzing a family of valves *with the same maximum lift,* or as a comparison method for obtaining one particular flow rate with various valves.

The second common method of showing flow characteristics uses a logarithmic scale for the flow rate and a uniform scale for the lift, as in Fig. 3-2. The logarithmic scale has the advantage that the *percentage change* of flow can be observed as accurately at low flows as at high flows. For example, if the maximum flow is 100 gpm, a change of 1 gallon from 3 to 4 gpm (or 33% increase in flow) occupies as much abscissa length as a 10-gallon change from 30 to 40 gpm (also a 33% increase in flow). Hence the percentage accuracy is the same at both 3 and 30% of flow on the semi-log plot.

In plotting flow on the logarithmic scale, as many decade cycles are used as are needed. When two are used, one is from 1 to 10, the other from 10 to 100. When three cycles are used, a third scale of 0.1 to 1 permits plotting of flow characteristics at critical low lifts just as accurately as through the upper range.

Types of Characteristic

Almost any flow-characteristic curve can be obtained by shaping the main valve or the ports of a valve, or by manipulation of the opening and closing movement. Flow characteristics fall into four major classes. Innumerable variations of these classes occur due to inherent design of the valve or can be engineered into the design to fulfill a special requirement. The four general classes are:

1. Quick opening
2. Linear
3. Modified linear
4. Equal percentage

Quick-Opening Plug Valve

Quick-opening valves are often called poppets. The quick-opening valve shown in Fig. 3-3,A maintains a straight-line relation between flow and lift through about 70% of the stem travel. However, the plug is designed so that full capacity is reached with short stem travel because the annular space between the seat and plug becomes equal to the area of the seat orifice with a travel of only about $1/4$ of the seat diameter. For example, if the seat has a 2-inch diameter, a valve lift motion of only $1/2$ inch is required for fully-open operation. (This compares with a valve lift of 1 inch or more for most contoured-type valves.)

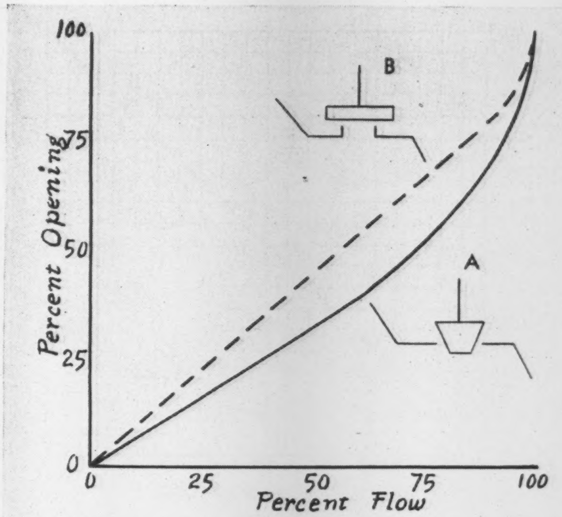


Fig. 3-3. Quick-opening plug valve (A) or disc valve (B) reaches full-open position with only small stem motion. Plug valve has linear characteristic (solid line) through 70% of useful travel; disc valve has linear characteristic (dotted line) until fully opens.

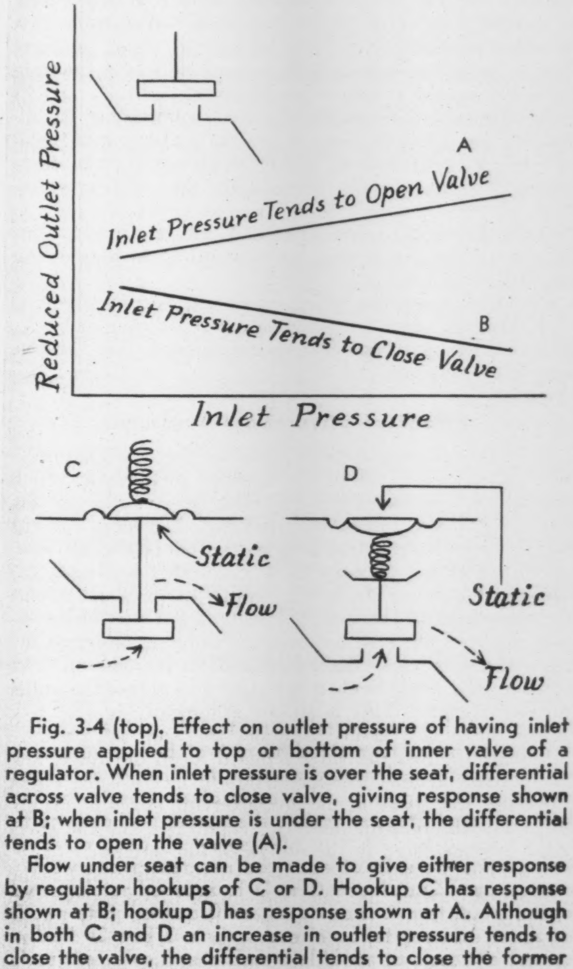

Reduced Outlet Pressure
A
Inlet Pressure Tends to Open Valve
Inlet Pressure Tends to Close Valve
B
Inlet Pressure
C
Static
Flow
D
Static
Flow

Fig. 3-4 (top). Effect on outlet pressure of having inlet pressure applied to top or bottom of inner valve of a regulator. When inlet pressure is over the seat, differential across valve tends to close valve, giving response shown at B; when inlet pressure is under the seat, the differential tends to open the valve (A).

Flow under seat can be made to give either response by regulator hookups of C or D. Hookup C has response shown at B; hookup D has response shown at A. Although in both C and D an increase in outlet pressure tends to close the valve, the differential tends to close the former but open the latter.

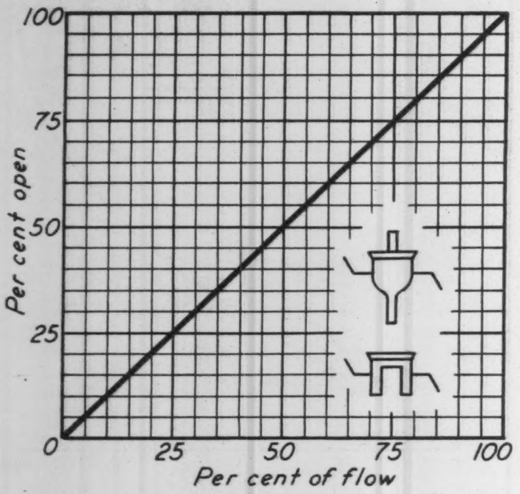


Fig. 3-5 Rectangular port or shaped plug gives linear characteristic.

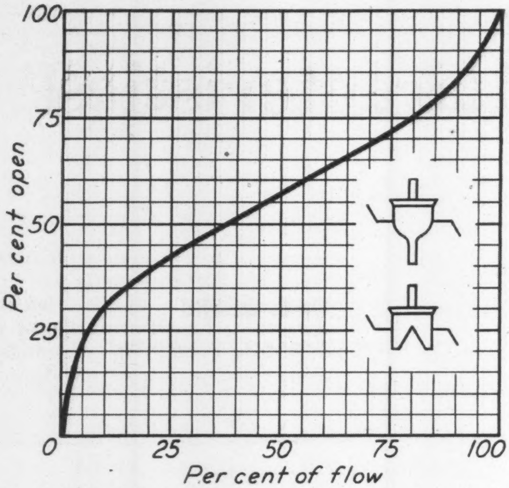


Fig. 3-6. Modified linear characteristic can be obtained by shaping the plug or V-port. This gives better control of low flows.

The quick-opening valve is used extensively in self-actuated control valves, commonly known as regulators. It is adaptable to on-off control or for systems with a constant pressure drop, such as one in which constant flow is being maintained from a surge tank to a fractionating column of constant pressure.

Guiding of the single-seated valve is important for effective shut-off, and also to maintain the spatial relationship of plug to seat. Many single-seated valves are top-and-bottom guided, particularly for high-pressure-drop service. A spring often is used under the plug to balance the weight of the plug and connected parts, thus decreasing the positioning forces required to obtain best results.

Although good shut-off (or lock-up) can be obtained with this style valve by using a well-lapped plug and seat, a soft-leather or rubber seat should be used when positive lock-up is required.

Effect of Differential Pressure

Note that no reference is made on the flow characteristic curves in Fig. 3-3 to the direction of the flow, which determines whether the high inlet pressure is on the underside or the upperside of the seat. The service of the valve (pressure reduction or pressure relief) and the manner in which the pressure to be controlled acts upon the actuator determine the way in which the pressure affects the movement of the seat. For example, if the inlet pressure is above the seat, the pressure differential across the valve tends to close the valve, and an increase in inlet pressure also tends to close the valve and reduce the outlet pressure further. This is shown graphically in Fig. 3-4. When the inlet pressure is under the seat, the pressure differential across the valve tends to open the valve, and an increase in inlet pressure tends to increase the outlet pressure. The shape of the characteristic curve is not appreciably different for these two conditions, but the effect must be considered in the design of the actuator.

This *unbalanced force* across a single-seated valve is the difference between the inlet and outlet pressures (or differential pressure) times the seat area. Use of a single-seated valve of any design is limited to the ability of the actuator to position the main valve properly while acting against this force.

Quick-Opening Disc Valve

Valves of the quick-opening disc type (Fig. 3-3,B) maintain a straight-line characteristic until close to full opening. Stem travel for full capacity is almost the same as for the beveled poppet type. Positive lock-up is possible by using a soft face on the flat plug. Most household gas-regulators are of this type.

Linear-Characteristic Valve

A linear flow characteristic can be obtained by rectangular ports or by a shaped plug (Fig. 3-5). This type of inner valve is indicated when a large portion of the system pressure-drop may be taken across the control valve. The shaped plug rather than the rectangular port should be used for maximum capacity because for a given size of valve and seat ring, the "full-open" flow of the plug is greater than that of the port.

The principal difference between the linear port and plug of Fig. 3-5 and the linear disc (poppet) of Fig. 3-3 is that the former requires a larger change in valve stem travel for a given change in flow rate. This means that flow can be controlled more accurately by the former. Actuators capable of positioning the main valve through its entire travel have been developed to make use of the high degree of control available from the longer stroke.

Modified Linear-Characteristic Valve

The modified linear characteristic shown in Fig. 3-6 is representative of what can be obtained by shaping the plug or V-port. Although often called "V-port" and "parabolic plug," the term "modified linear" is more descriptive.

These shapes may be applied to inner valves of widely varying travel. Note that at low rates of flow the stem must travel a relatively large distance to obtain a small change in flow (30% travel is required for 10% of flow); this results in good control of low flows. The linear portion means that at high rate of flow a small change in valve movement makes a large change in flow (a useful characteristic).

The parabolic (or modified-linear) characteristic is obtained from a V-ported plug because the area of the triangle being covered (starting at its vertex) plotted against the altitude (stem travel) is parabolic in shape.

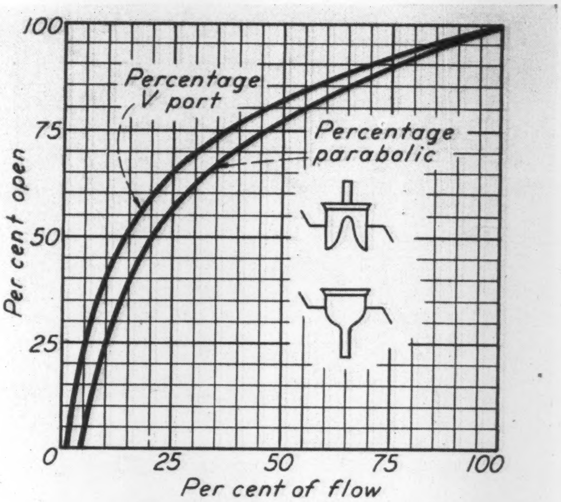


Fig. 3-7. Equal-percentage (or logarithmic) character-stic gives good control over wide range of flow.

he contour of the parabolic plug is designed to give a imilar curve.

The V-port was an early advance in valve-port design, nd it offered the advantage of high lift, which allows asier positioning of the plug for a given flow condiion than does the quick-opening poppet. These valves vith modified linear characteristic can be designed also or low lift, with the same characteristic occurring withn a shorter travel. However, this low-lift design lacks *angeability* (the ratio of maximum to minimum flow ver which the usable flow characteristic exists).

Note in Fig. 3-6 that the control sensitivity is decreased oth at low flows and at high flows. This is an advantage t low flows where it is desired to have large valve moion result in small flow change. However, this is a disdvantage at high flows where it is desirable to have arge changes in flow. The equal-percentage-type valve vercomes this disadvantage at high flow.

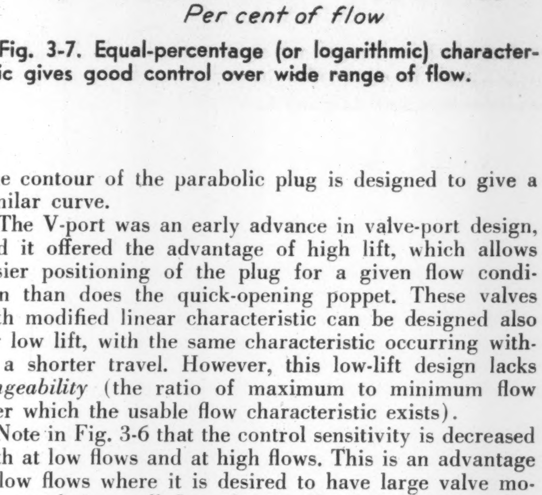


Fig. 3-8. A piston valve consists of a movable cylinder vith ports (A) or a stationary cylinder whose port opening s controlled by a movable piston (B).

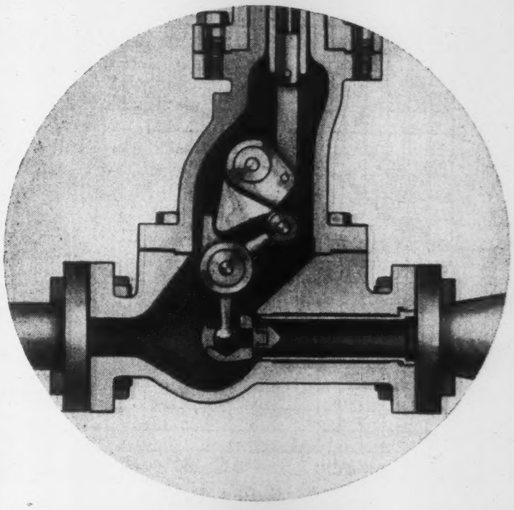


Fig. 3-9. Streamlined design of this inner valve reduces erosion effects and prevents ice or frost accumulation (for vapor service). Plug shown has quick-opening characteristic.

Equal-Percentage-Characteristic Valve

V-port and parabolic-plug valves can be machined to give a wide variety of flow characteristics. Fig. 3-7 shows the important equal-percentage (or logarithmic) characteristic, which was developed in an effort to obtain good control over a wide range of flow and pressure changes. As described previously, the equal-percentage flow characteristic produces a constant *rate of change in flow* for unit change in lift.

Many chemical-plant variables fluctuate in a nonlinear manner. For example, nonlinearity occurs when line pressure drops vary considerably from low flow to maximum demand. Under these conditions the pressure drop across the valve may be a small percentage of the system drop at maximum flow, but a large percentage at small flows. The equal-percentage valve makes it possible, theoretically, to control a wide range of these changes with one size of valve.

Comparison of the equal-percentage plug with the V-port shows that the plug is less susceptible to erosion, less apt to stick and, in most cases, less apt to create high-frequency noise. However, the weight of large shaped plugs becomes excessive, despite the fact that the plugs now are being made as a hollow shell to minimize weight.

Further discussion of the advantages of the equal-percentage characteristics is included in a later chapter.

Piston Valves

A piston valve consists of a movable cylinder with ports, which can move within the seat area (Fig. 3-8, A), or a stationary cylinder with ports which are opened by a piston moving within the cylinder (Fig. 3-8, B). Any shape of porting is possible.

The pressure differential across the valve in this design does not tend to open or close the valve and therefore the inner valve is better balanced than is the conventional double-seated globe valve (which must have one seat area larger than the other to make possible the removal of the inner valve from the body).

Leakage occurs around the piston at partially open positions and can be controlled only by close machining, with due consideration of operating temperature and

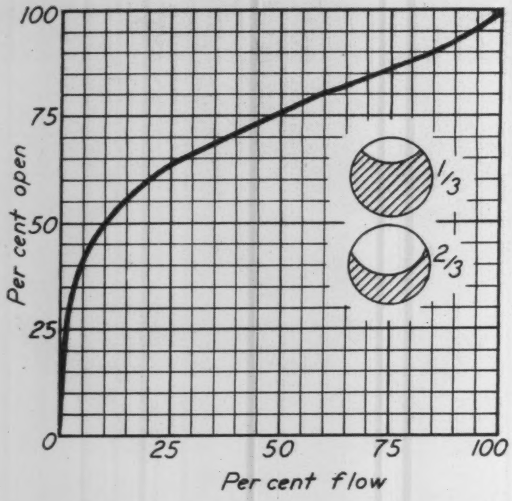


Fig. 3-10. Plug cock. Port area in plug cock with circular hole in plug varies as two converging circles. Flow characteristic is linear over last third of lift, and controls three fourths of the flow in this linear region.

pressure conditions. Bevel seats may be used to minimize leakage in the closed position.

The inner valve in this design is guided over a great length due to the piston moving within the seats or the cylinder: this guiding minimizes vibration or chatter caused by flow through the ports.

Plug Cock (Full Opening)

Plug cocks consist of a body into which a plug is inserted. The plug has a hole through it so that 90-degree rotation of the plug will open or close the cock.

Many plug cocks in service today have semi-rectangular ports. However, this shape does not create a desirable flow characteristic because the port area is that subtended by a rectangle crossing a circle. In the full-opening cock with a circular hole in the plug, the port area varies as two converging circles (Fig. 3-10), and the flow characteristic approaches linearity through the last one third of its lift—and controls three fourths of the flow in this linear region.

Even under ideal operating conditions, the plug cock requires more power for positioning than many other valves. Neglect of servicing causes sticking (which in one known case reached such proportions that the handle of a 36″ wrench being used on a 4″ cock was broken with a snipe before the cock broke loose). With proper care, and with an actuator with sufficient power, the plug cock can be used successfully for control.

The positive shut-off obtainable has made the plug cock standard in gas distribution. Many control installations have been brought about by the necessity for using gas-distribution systems in a diversified manner.

Plug Cock (Restricted)

One form of plug cock allows for shaping the aperture through which flow occurs. The flow characteristic shown in Fig. 3-11 is obtained when a V-port is progressively closed by the circle. This type of cock has been used successfully on gas- or oil-fired heaters in which the air and fuel valves are mechanically connected and operated simultaneously.

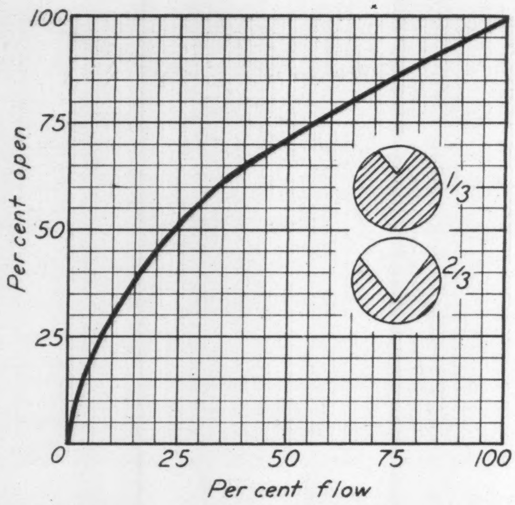


Fig. 3-11. Plug cock with V-port has characteristic that approaches that of the equal-percentage type, providing better control of flow and high flows than plug cock with circular port.

Streamlined Plug Valve

Streamlined design reduces losses created by turbulence or a partial vacuum. Valve body and plug design which minimizes changes in direction of flow and the attendant turbulence should have advantages over other designs. Oddly enough, only a few control valves are available which capitalize on these advantages.

A streamlined design is shown in Fig. 3-9. When used as a pressure regulator this valve requires only a small movement (full flow occurs with a travel of a little more than $\frac{1}{4}$ of the throat diameter) and the characteristic flow curve is similar to that in Fig. 3-3. The plug could be shaped to produce a parabolic flow curve; the movement of the plug would also be increased.

Note in Fig. 3-9 that the plug centers itself on the seat in the closed position. Other advantages of this valve are (1) the working parts are free of erosion effects (the scouring action takes place in the discharge throat where it does not affect the seating or characteristic of the plug) and (2) for vapor service the vapor expansion occurs away from the moving parts at a point where ice or frost cannot accumulate. The capacity of this body style is considerably greater than of most single-seated valves. This body has not been built in large sizes.

Rubber Pinch Valve

The rubber pinch valve uses the same principle as the laboratory rubber hose and pinch clamp. As shown in Fig. 3-12, the valve can be considered a streamlined valve; in fact, it comes close to being a variable Venturi.

Advantages include shut-off on coarse particles and operation under freezing conditions (which can cause trouble with metal globe valves). It can be employed for pulp stock and liquids containing abrasives because the fluid does not contact any operating parts. The valve comprises a fabricated sleeve of pure gum rubber or a synthetic, as selected for the service. This liner is covered with long bias weave type cloth which is impregnated with rubber and then wrapped around the tube. The valve body, or tube, is made with slip-on clamp ends or flanges conforming to 125-psi ASA dimensions.

Throttling is accomplished by a pinch clamp device.

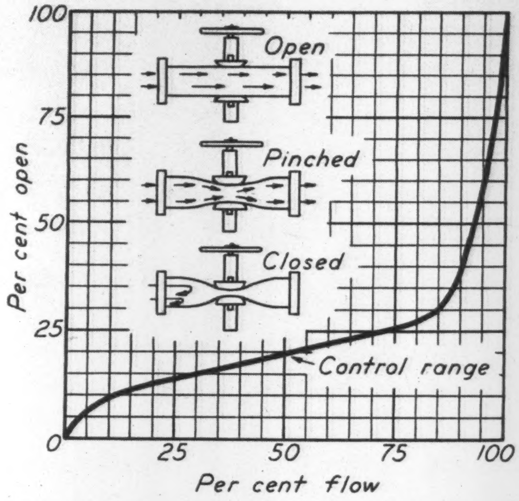


Fig. 3-12. Pinch valve approximates a streamlined valve or variable Venturi, and provides shut-off of coarse particles and operation at freezing conditions.

The valve can be used for control applications by operating the pinch clamp with a suitable actuator. The flow characteristic (Fig. 3-12) shows that 90% of the flow is obtained with fairly linear characteristic through the *first third of the travel* of the pinch clamp; as this portion of the curve is used for control, it is important that the correct valve size is selected upon this basis.

The pressure in the line will return the valve to the open position when the force of the clamp is released; hence a spring is not required in the actuator. For this reason an air-to-open valve (one that closes on air failure) can be obtained only by special design of the actuator. The valve body and actuator must be installed in a position which allows the tube to be compressed from both sides.

Saunders-Type Valve

Design of the Saunders-Patent valve (Fig. 3-13) is such that flow through the body is over a transverse weir. Closure is obtained by compressing a dome-shaped diaphragm upon this dam. In "full-open" position, the aperture is a pointed ellipsoid.

The flow characteristic is similar to that of a pinch valve (Fig. 3-12). The portion of the curve up to 50% open can be used for control of about 77% of the maximum capacity, but the flow/lift ratio decreases rapidly through the remainder of the valve travel. The shape of this characteristic and the portion of the travel applicable for control varies with the ratio of pressure drop through the valve to system pressure drop. It is a fortunate circumstance that the valve has a usable control characteristic at all because the valve was designed primarily for complete shut-off, corrosion resistance, and high ratio of internal area to pipe size.

The near-streamline flow obtained in this valve produces a self-cleaning action so that the body may be used for sludges or viscous liquids. Sand or foreign matter carried by the liquid in the line will not interfere with tight closing (assuming that sufficient power is available to depress the diaphragm).

Table 3-1 shows maximum allowable working pressures for common bodies and body linings in the sizes listed.

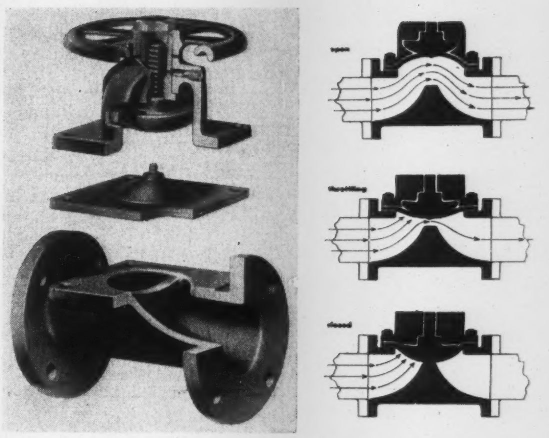


Fig. 3-13. Flow in Saunders-Patent valve is over a weir against which a dome-shaped diaphragm is pressed. Flow characteristic is similar to that of a pinch valve.

Table 3-1.—Working Pressures (PSI) for Saunders Bodies

Size of Valve	½" to 4"	5" and 6"	8"	10" and 12"	14"
Cast Iron and Alloy Bodied Valves	150	125	100	65	50
Cast Iron Bodied Valves with Glass Lining	150	125			
Cast Iron Bodied Valves with Rubber Lining	150	125	100	65	50
Aluminum Bodied Valves	90				

Saunders valves are made in sizes from ⅜" through 14", and from any metal that may be cast. The shape of the body adapts itself to successful lining with anything from glass, Saran, plastics and tin to synthetic or natural rubbers. Diaphragms can be molded from rubber, Teflon or Kel-F; Kel-F has found use as a diaphragm material for severe chemcial services which attack rubber and synthetics. A molded diaphragm of this material is tough and flexible, but not resilient; hence a rubber cushion is used to back up the Kel-F diaphragm to provide resiliency and support.

Throttling control with a Saunders valve can be obtained by applying pneumatic or hydraulic pressure directly on the upper side of the diaphragm. This method is not recommended for high pressure-drops or high line-pressure because of detrimental effects upon the diaphragm.

The great variety of body and diaphragm materials available gives the engineer a chance to select the optimum material for each service. As this valve is often used in services where other valves cannot be used, such as where the fluid must not contact the working parts, periodic inspection is essential to guard against failure of diaphragm or linings.

Rubber-Sleeve Valve

The body of the rubber-sleeve (or expansible sleeve) valve consists of a circular slotted cage with a barrier in the middle (Fig. 3-14); a synthetic-rubber sleeve envelops the cage. An annular space in the valve body allows the tube to expand and to permit flow past the center barrier. The valve may be considered as a pinch

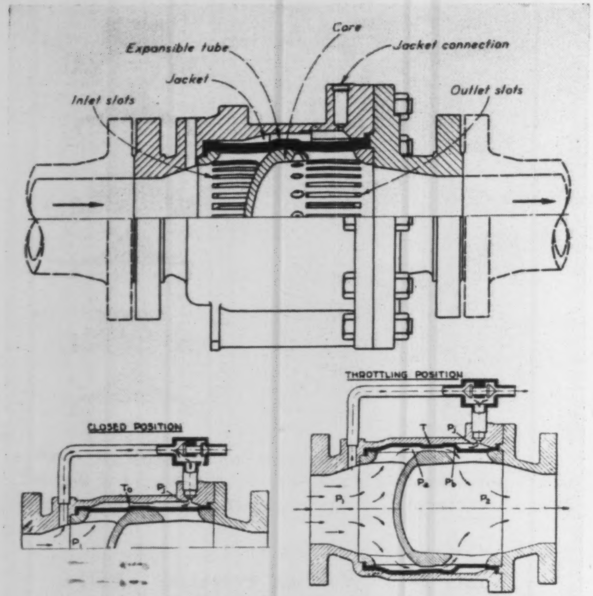


Fig. 3-14. In the expansible-sleeve valve, a rubber sleeve envelops a cage with slots on a solid core. Expansion of the sleeve permits flow through the slots and past the center barrier core. Use of a pilot valve to control the pressure exerted upon the sleeve permits throttling control.

Table 3-2.—Inlet Pressure Required to Expand Standard Hycar Tube of Flexflo Valve and Open Valve.

Flexflo Size	Low-Pressure Flexflo[1]	Medium-Pressure Flexflo[2]	High-Pressure and Extra-High-Pressure Flexflo[3]
1"	19		60
1¼" and 1½"	10	25	40
2"	7½	19	30
2½"	6	15	24
3"	5	12½	20
4"	5	12½	23
6"	4½	11½	20
8"	3½	9	9
10"	4	10	10
12"	4	10	10

[1] Flexflo is a tradename of the Grove Regulator Co. The low-pressure valves are designed for 200 or 230 psi max. CWP.

[2] Medium-pressure design is for 400 or 600 psi max. CWP.

[3] High-pressure design is for 1200 psi; extra-high-pressure is for 1440 or 1500 psi.

valve because closure is obtained by introducing pressure into the annular space outside the expansible tube.

The valve offers advantages similar to those of the pinch tube or Saunders valves—the sleeve does not stick and does not slam or chatter as do metallic valves, it will envelop foreign matter to close tightly, and within the limits of temperature and chemical attack it resists wear and erosion.

The valve is suitable for service with fluid or gas carrying abrasives because the degree of tightness does not depend on the condition of the seating surface. Wear in the slots of the cage is not important unless it reaches the point of cage breakdown. The valve has no moving metallic parts in contact with the flowing fluid, but the cage cannot be protected easily by coating with plastics; proper selection of body material is the only protection against corrosion.

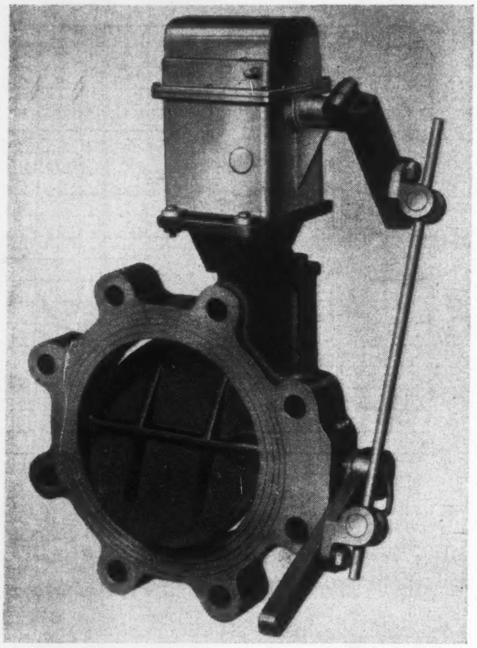


Fig. 3-15. Typical butterfly valve. Damper can be circular or elliptical.

As line pressure opens the valve, it cannot stick in the closed position and it always closes if sufficient pressure is applied in the annular space. Direction of flow is unimportant. Line pressure from the high side of the valve is generally used to operate the action of the sleeve, although external pressure can also be used.

Throttling action can be obtained by use of a pilot valve to control the pressure exerted upon the rubber sleeve, as shown in Fig. 3-14. The flow characteristic and mode of operation (on-off, remote-manual, throttling, etc.) depends on the pilot valve used to load the rubber sleeve.

In determining the capacity of this valve, it is necessary to consider the full expanding pressure for the valve which must be deducted from the differential pressure to be expected across the valve to determine the effective pressure drop. Table 3-2 shows the expanding pressures required for various sizes of expansible-sleeve valves.

The "Expanding Pressure" is the inlet pressure required to expand the sleeve and open the valve. The tube tension tends to hold the valve closed; thus the effective closing pressure is the pressure introduced into the jacket (space between body and sleeve) plus this expanding pressure. By the same analysis, the effective pressure drop used for sizing is the actual pressure drop minus this expanding pressure.

When used as a pressure regulator, the minimum operating pressure drop through the regulator is normally taken as twice the tube expanding pressure. Hence 10 psi is the minimum drop through a low-pressure 3″ valve. A larger drop is required in smaller sizes. With special hookups the regulator can be used at lower differentials, even differentials below the tube expanding pressure.

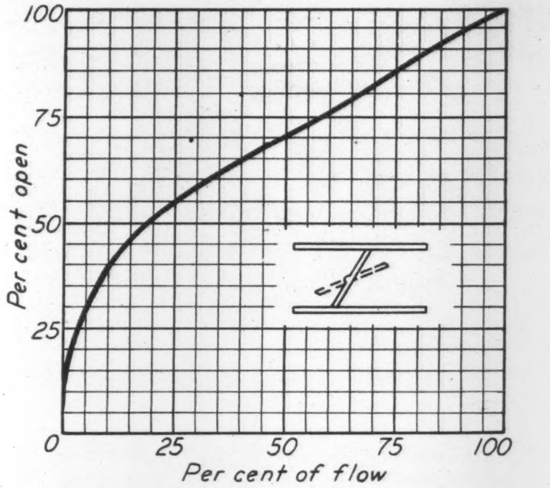


Fig. 3-16. Flow characteristic of a butterfly valve has an equal-percentage curve for first 50% of lift (or 20% of flow), and a linear characteristic for the remainder.

Butterfly Valves

The term "damper" is used in this discussion for louvres that control the flow of combustion air into the firebox of a boiler, or to regulate the air flow produced by the fans of a forced-draft cooling tower. Butterfly valves are often employed for this service and will be called dampers when so used.

Butterfly valves have evolved from the original use as devices employed with low pressure-drops and low static-pressures (where control is not critical and leakage is not a factor) to control valves worthy of consideration for a wide variety of applications.

Economy is an important factor in favor of the selection of a butterfly valve for a given service. Size for size, the butterfly valve passes approximately 50% more volume than the double-seated globe valve can handle.

An approximate capacity (C_v) of a butterfly valve can be determined by multiplying the square of the diameter of the valve by 16. (The constant 10 or 12 is typical for double-seated globe valves.)

The design is simple (Fig. 3-15), consisting of a shell or body, a damper blade, shafting to hold the blade, and stuffing boxes to allow the shafting to protrude outside the body for operation. The butterfly valve is self cleaning, which allows its use for control of stocks and sludges.

A butterfly valve designed to close in a vertical position (rather than at an angle) is much less expensive to manufacture due to the use of a circular rather than an elliptical damper. The angle type, which may seat at about 10 or 15% off the vertical, can be made to shut tighter with less chance for sticking. Clearance and leakage are minimized with the angle type, but clearance is still required in the vicinity of the shaft. Use of a rubber-insert sleeve has made it possible to obtain drip-tight closure.

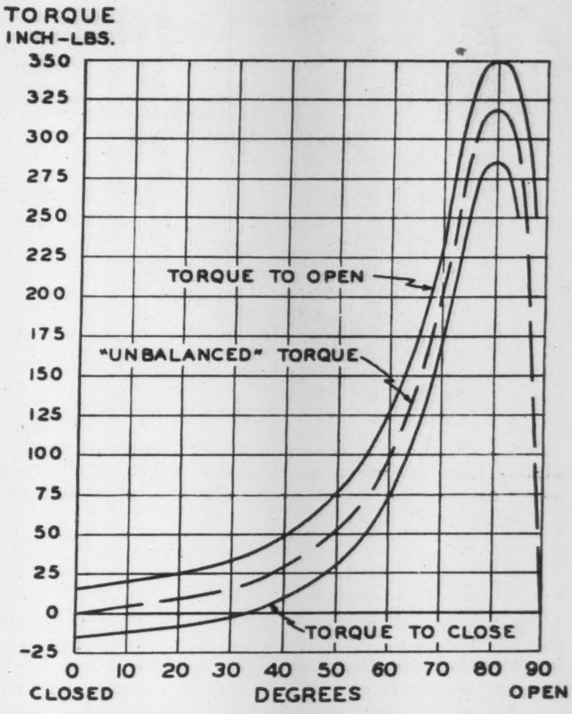


Fig. 3-17. Torque characteristic of a 10" butterfly valve with constant 1-psi drop across the valve.

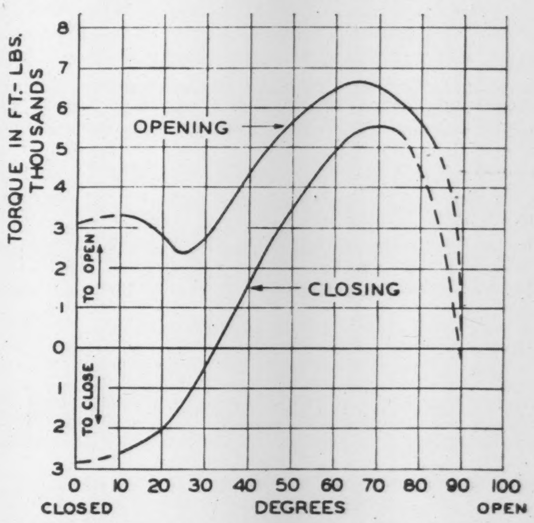


Fig. 3-18. Operating torque of a 24" butterfly valve controlling water flow.

The flow characteristic (Fig. 3-16) resembles an equal-percentage curve for the first 25% of flow, and a linear curve for the remaining 75% of flow. The contour or shape of the damper has little influence on the characteristic. (The "percent open" scale for a butterfly characteristic refers to percentage of angular rotation. The angular rotation is 90 degrees for a valve that closes in a vertical position, and is 75 degrees for a valve closing at 15 degrees from the vertical position.)

Torque-characteristic of a butterfly valve must be given more careful consideration than is required for other valve designs. At positions other than full open, the pressure on the disc produces a large torque which reaches

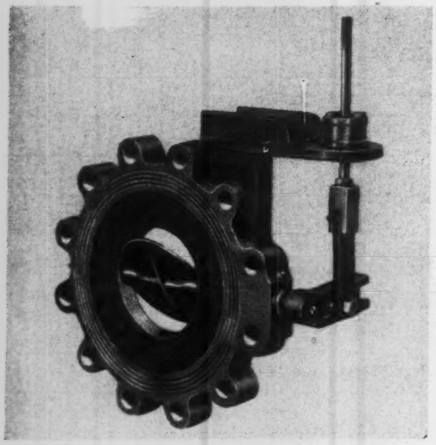


Fig. 3-19. Use of a small disc permits butterfly control of low flows. A movable small disc within a movable larger disc also can be used for good control action over a wide range of flow.

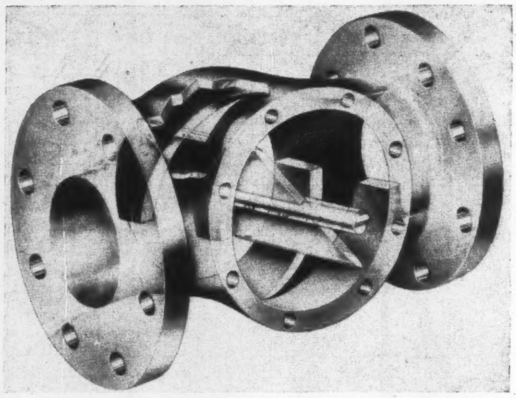


Fig. 3-20. In the V-port butterfly the vane uncovers two V-ports, resulting in greater control sensitivity at low flows and greater flow per degree rotation at high flows—two desirable characteristics.

a maximum at a position between 60% and 90% open (Fig. 3-17). The torque then drops off rapidly as the valve continues to open. In large valves this torque requires use of a powerful actuator, as shown in Fig. 3-18. Nomographs are available showing the torques required to operate butterfly valves of various sizes for various pressure-drop ratios. (Pressure-drop ratio is the ratio of line pressure to the pressure drop at 60 degrees open.)

The butterfly valve is not a balanced valve, and the pressure drop plus the thrust force of the flowing material causes two types of torque—unbalanced and static. Except at the fully open or closed positions, the thrust load on the upstream wing is greater than that on the downstream wing. This *unbalanced* (or hydraulic) torque always tends to *close* the valve. The *static* torque is the bearing frictional force that always resists the motion of the shaft in either direction. The total torque required to open the valve is the *sum* of the static and unbalanced torques, whereas the torque required to close it is the *difference* between the torques (as shown in Figs. 3-17 and 3-18). The equations for unbalanced torque (T_u) and static (T_s) are:

$$T_u = G(\Delta p)(d^3)$$
$$T_s = (f)(J)(d/2)(\Delta p)(A)$$

where G is an unbalanced-torque coefficient, d is diameter of disc, f is friction coefficient for the bearing, J is a thrust coefficient, and A is disc area.

Selection charts for butterfly valves usually make it possible to size a valve so that full usable capacity is reached before the point of maximum torque is reached because good control is difficult in the region where the torque increases or decreases rapidly. This is because the power required to gain stability is greater than is necessary to counteract the torque. This condition is greatly aggravated by flashing liquids.

Thrust characteristics are so important in the selection of a butterfly valve that the thrust force frequently becomes a limiting factor governing usable pressure drop.

Some reduction or balancing of the torque can be effected by changing the disc shape, changing the shape of the line housing the valve, counter-balancing, and moving the position of the shaft. Each of these changes may be successful for a particular installation, but usually only for limited operating conditions.

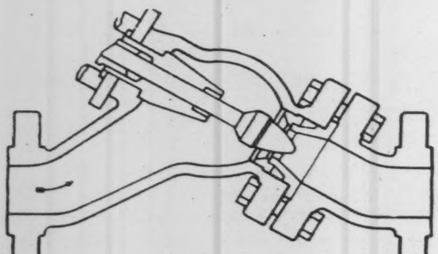


Fig. 3-21. Diagonal seat gives streamlined S design that reduces erosion and minimizes change in direction of flow.

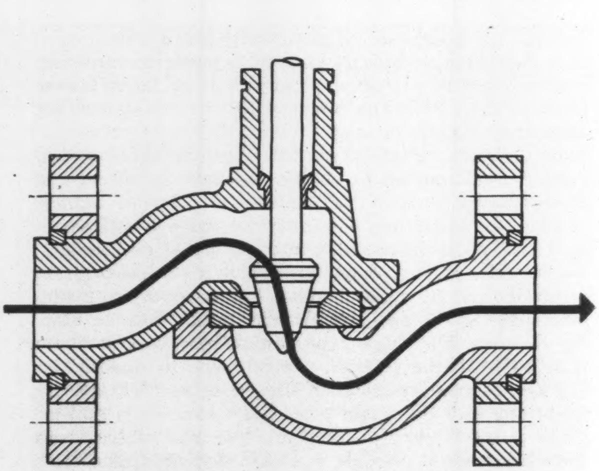


Fig. 3-22. S-valve with upright stem.

Wide range of flow control has been accomplished by a design which incorporates a small disc operating within the surface of the full-sized damper. Fine control can be obtained by a reduced port in a line-sized flange (Fig. 3-19).

V-Port Butterfly Valve

V-ported butterfly valves were designed primarily for metallurgical-furnace control. The valves (Fig. 3-20) consist of two V-ported surfaces engaged by a close-fitting butterfly vane; the flow characteristic can be varied by shaping the V-port. This valve gives better control action than the conventional butterfly valve because (1) the flow change per degree of angular travel is greater at the high flows (where this change is required most), and (2) at low flow rates a greater angular movement is necessary. This valve approaches the operation of a globe design, with its relatively high pressure drops in the open position.

Streamlined S Valve

In an effort to minimize erosion and to handle sludges or vapors containing entrained liquids, a logical approach is to try to eliminate changes in direction of the flow by installing the seat diagonally so that a figure "S" is simulated (Fig. 3-21). This design is applicable only to a single-seated valve.

Mechanical problems arise in obtaining proper alignment when the main valve and the seat are on an angle or are widely separated. Alignment requires use of a husky stem and the guiding of the stem by about 5 diameters of bushing. The inner valve, which can be shaped from the end of the stem or screwed into it, is a plug rather than the V-port type, and can be shaped for the flow characteristic desired.

The S-valve flow pattern can be obtained also with a vertical stem, as shown in Fig. 3-22. This design has the advantage that (1) the valve is easy to remove from the line due to the manner in which the body is split and (2) the seat ring can be removed easily. Note that the body can be constructed for either straight-through or 90° flow, as shown in Fig. 3-23.

Large size of the seat ring and ease of removal give a high degree to flexibility to this construction. The ring can be hard-faced and can be ground easily. The seating surface subject to replacement can be a thin wafer sealed with Teflon. A soft seat can be used for tight shut-off.

Angle Valve

Using a valve in which flow comes in the side and goes out the bottom probably originated from the necessity to install a valve in a line where the valve had to be installed at the turning point. An angle valve (Fig. 3-24) has three advantages: (1) it is simple to remove it (at least the flanged type) from the line; this contributes to the ease of replacing the seat, (2) the upper portion of the tee forms a natural framework to hold the long guide necessary for this style of valve, and (3) it can handle sludges or erosive materials at high velocity with a minimum of turbulence and erosion.

The epitome of this style is the use of a wide-radius bend as the inlet to the valve plug and seat (Fig. 3-25). Construction of seat and outlet throat of this valve to simulate a Venturi has given it several advantages: (1) Low pressure drop for a given flow results in as much as one third higher capacity than for the globe valve of the same size. (2) Low erosive effects allow the angle valve to handle pressure drops as high as 4,000 psi in sizes up to 8 inch. (3) Flow efficiency is high. (4) There

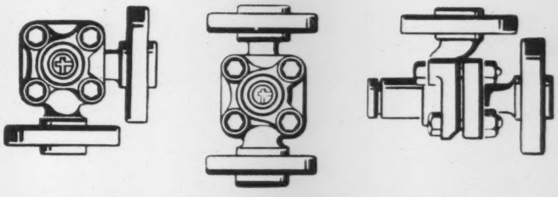


Fig. 3-23. Split-body design allows variety of installation positions for straight-through flow, angle flow, etc.

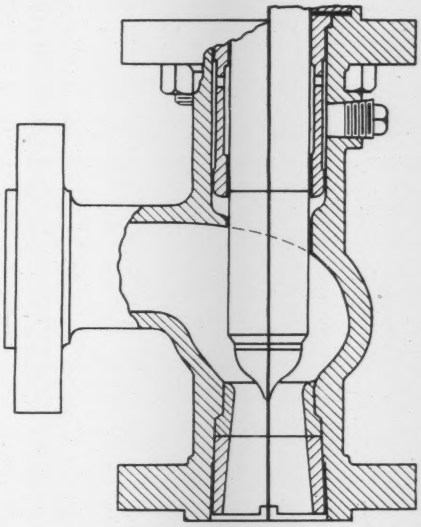


Fig. 3-24. Angle valve has advantages: (1) it is easily removable from line, (2) there is room for a long stem guide, and (3) it can handle sludges and erosive material at high velocities.

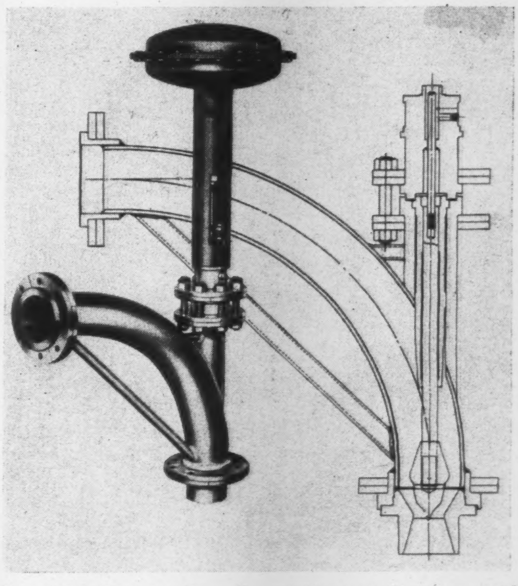


Fig. 3-25. Long-radius ell and Venturi throat provides advantages of (1) low erosion, (2) high flow efficiency, (3) less tendency for flashing and turbulence, and (4) ability to handle sludges and solids in suspension.

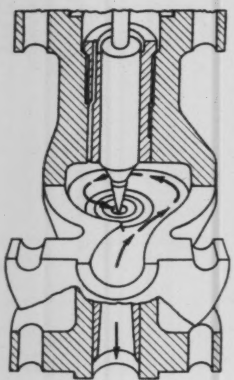
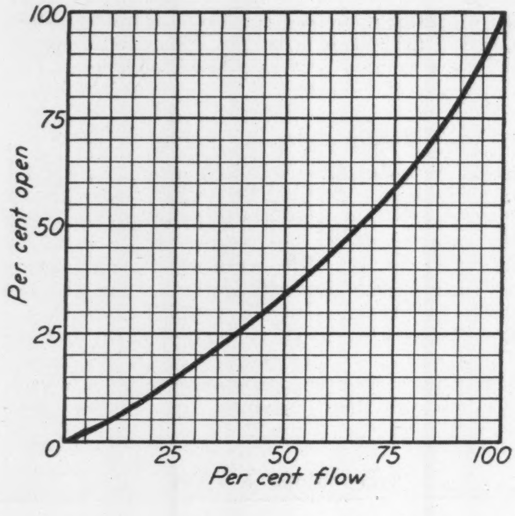


Fig. 3-26. Angle valve with circular flow pattern for applications involving high pressure-drops and flashing. Characteristic is fairly linear, with decreasing flow sensitivity at high flows.



is less tendency in the valve body for flashing or for turbulence causing separation of solid particles from sludges, with attendant erosion.

Flushing connections can be provided for difficult sludge conditions. Stem design in which the pressure tending to open the valve from a closed position is balanced to obtain tight shut-off has done much to allow the angle valve to be used where high pressure-drops must be handled.

Another angle-valve design attacks the problem of high pressure-drops and flashing liquids by creating a *circular flow* (Fig. 3-26). The circular flow minimizes impingement on the walls of the valve body and is purported to center the plug above the opening in the Venturi seat plug. The flow characteristic is fairly linear through 60 percent of the valve travel (controlling 75% of the flow) with decreasing flow sensitivity near full-open position.

Adjustable Rectangular-Port Rotary-Piston Valve

Wide variation in flow capacity is obtained by the rotary valve shown in Fig. 3-27. As the shaft is turned the piston rotates and also moves vertically to open or close the rectangular port area. Any portion of the port

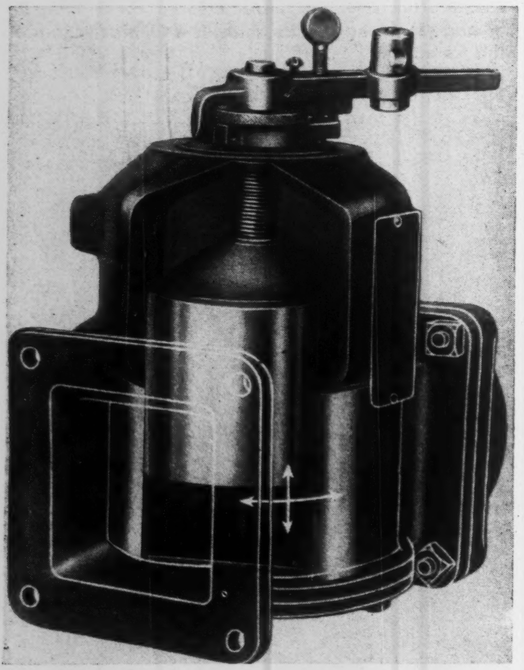


Fig. 3-27. Rectangular-port rotary-piston valve is a type of gate valve. As shaft is turned, piston rotates and also moves vertically to open or close port areas. Flow is straight through the body. Valve has wide variation in flow capacity.

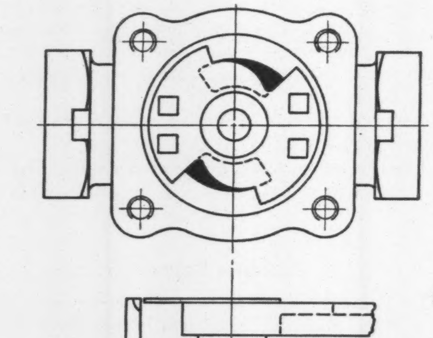


Fig. 3-28. Rotary disc valve is slide valve with a disc that is rotated to open or close the ports in the seat.

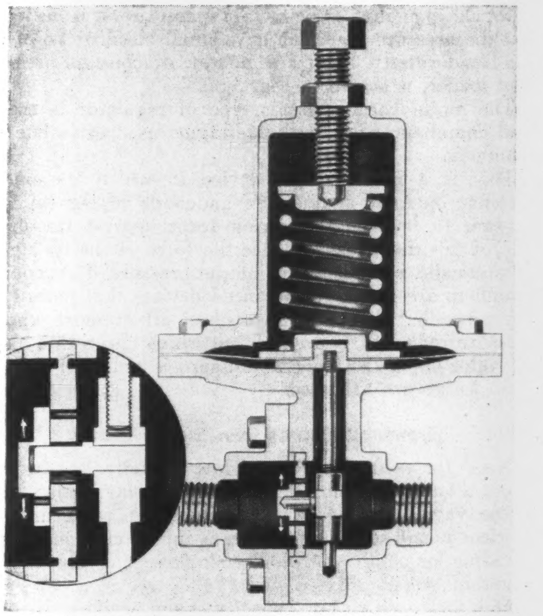


Fig. 3-29. Sliding-gate control valve opens or closes he ports in the stationary plate by moving a gate vertically. Ports are shown in open position at right, closed in he enlarged view at left.

rea may be utilized by adjustment with the handwheel. The flow is straight through the rectangular ports at the ront and rear. This valve is essentially a type of gate valve.

Rotary-Disc Valve

Many types of slide valves have been developed. One type (Fig. 3-28) consists of a disc, with openings, which s rotated to open and close the ports of the seat. The low characteristic is similar to that of a true V-port. This valve is made in sizes from ½ through 1¼ inch and can be used for services up to 150 psig and 400°F.

Slide Valve

Gate valves, either operated by screw stems or used as slide valves, are generally not considered as control valves because many other styles of valves are superior for control service. However, the sliding-gate valve shown in Fig. 3-29 has entered the control field. The flow is controlled by opening or closing ports in a stationary orifice plate with the aid of a sliding gate whose position is changed by raising or lowering the stem. The wiping action of the gate on the plate is used to keep the surfaces ree of adhering material. This valve is available in 2″ size and smaller. The flow through the ports is straight hrough the body. The ports may be shaped to obtain desired characteristics.

Remote Manual-Loading Valve

Remote control of a pneumatic actuator requires a device that will supply an adjustable and constant pressure o a dead-end system, such as the topworks of a diaphragm valve. A conventional valve (such as a needle valve) won't work because the output pressure will build up to the inlet pressure in any dead-end system. A valve and a small bleed can be used but, as clean dry instrument air

Fig. 3-30. Pilot loader is a pressure regulator useful for remote manual control of a pneumatic device. Output pressure working against underside of upper diaphragm balances spring force on top side of this diaphragm. Hence manual adjustment of spring compression establishes the output pressure. Lower diaphragm is used to control bleed-off valve when pressure reduction is called for.

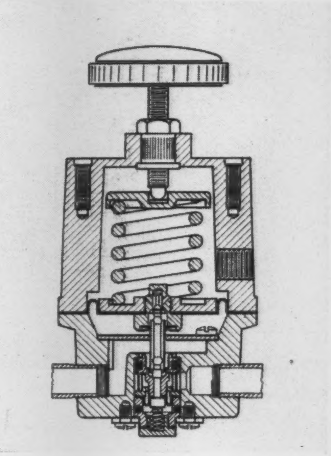


Fig. 3-31. Construction of a miniature control valve for low flows. Height is only 6 inches.

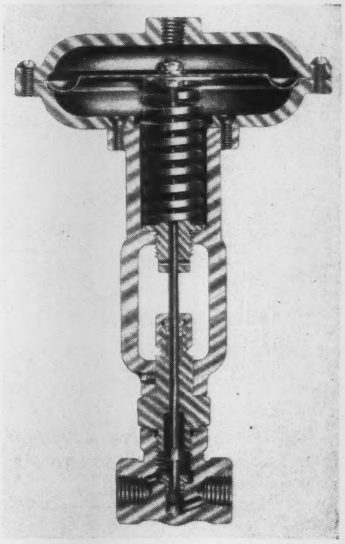
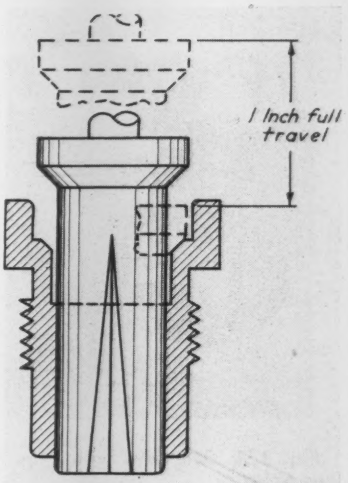


Fig. 3-32. Machining a flute in a small plug for control of low flows.



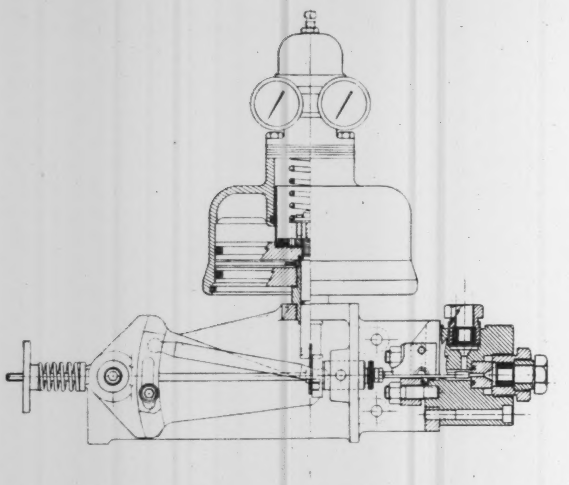


Fig. 3-33. Control valve for minute flows (C_v range of 10^{-6} to 10^{-1}) obtains micrometer horizontal movement by lever action.

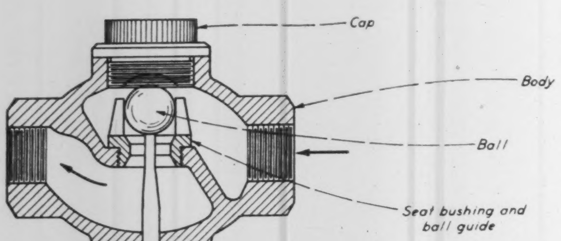


Fig. 3-34. Ball valve accomplishes good seating and long life because ball can rotate and continually expose new surface for seating.

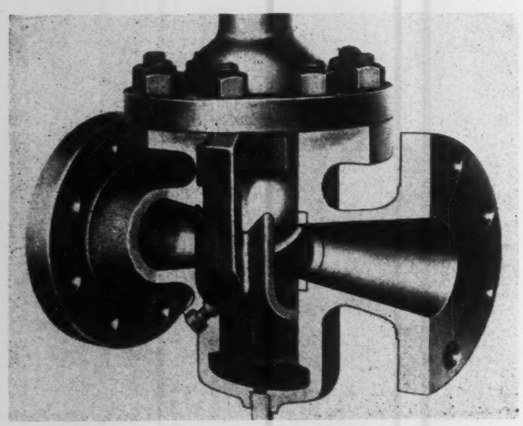


Fig. 3-35. Ball valve with cage holder for moving ball into place.

is not cheap enough to be bled in quantities, it is desirable that the pressure regulator have small bleed or be of the non-bleed variety. Such a regulator, or constant-pressure pilot loader, is shown in Fig. 3-30.

The main feature in this type of regulator is use of dual chambers, with two diaphragms used to isolate the chambers.

This is a force-balance device in which the output pressure operates against the underside of the top diaphragm to balance the spring force against the upper side of this diaphragm. Hence the force of the spring, as set manually, establishes the output pressure. The separate chambers are also force-balanced devices that permit the upper needle valve to open to bleed off pressure when a pressure reduction is desired, but which closes this bleed-off valve when the desired pressure is obtained and the main forces are balanced.

Control Valves for Small Flows

Need for control valves of low capacity has brought about a variety of plug designs under many trade names. These valves are needed for pilot-plant work and for services in full-scale plants such as injection of inhibitors, blending, or pump control. The single-seated valve is most adaptable to this service.

One approach to low capacity is the needle valve with percentage plug. The valve shown in Fig. 3-31 is only 6 inches high. This valve is available in a size as small as ¼ inch with a C_v of about 0.60. The manufacturer of this valve specializes in miniature diaphragm control valves of high quality.

A C_v of 0.001, corresponding to a water flow of 0.001 gpm in full open position with 1-psi pressure drop, can be obtained by machining a fluted plug (Fig. 3-32). As small seats and plugs are particularly susceptible to erosion, they are made of hardened steels. Often they are stellite-faced or even machined from solid stellite.

Capacity factors (C_v) as low as 0.0001 have been obtained by the use of a valve that consists of an angle body with a needle positioned by rotating the stem. This type of valve is available with maximum travel of as little as 0.0052 inch, with a positioner attached to the shaft.

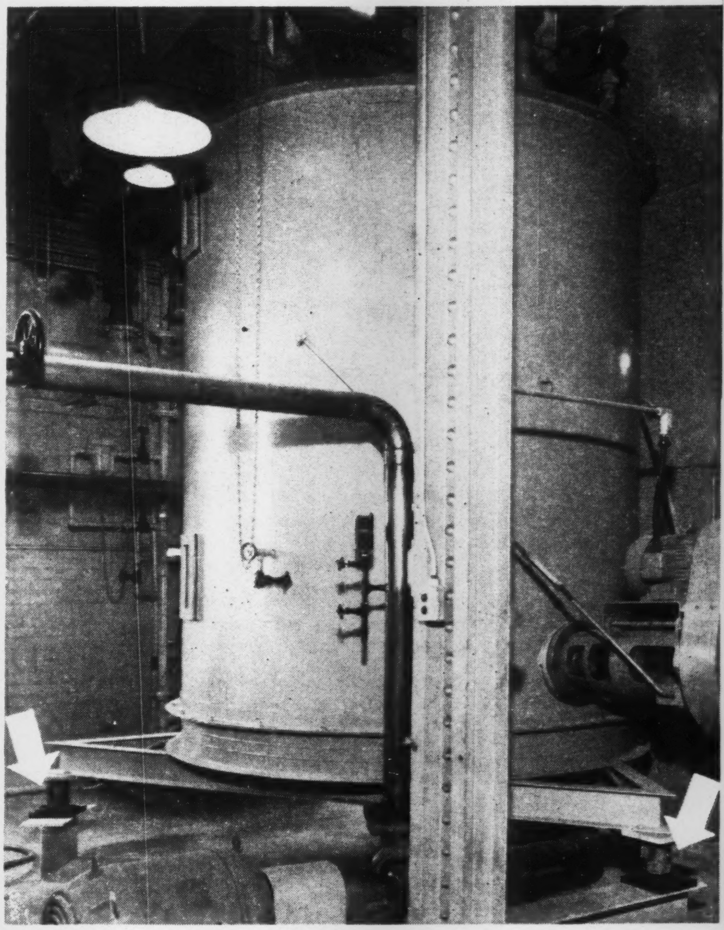
Another approach to the control of small flows (Fig. 3-33) employs an actuator capable of accurately positioning a vertical stem. This vertical travel is converted to a minute horizontal movement which positions the single valve plug in an angle body. The travel may be varied from 0.010 to 0.150 inch. The valve is designed for positive closing at 30,000 psig, with a C_v range of 0.000001 to 0.1.

Ball and Seat Valve

A unique design to accomplish good seating and long life is shown in Fig. 3-34. The valve is a ball which is lifted off the seat by the stem and returned to the seat by the force of the flow through the body. This valve usually is installed with the stem protruding downward. The ball moves within the guides and tends to last indefinitely due to constant movement, which continually exposes a new surface for seating.

Another adaptation of the ball is the use of a cage to move the ball into place (Fig. 3-35). In full-open position the port through the valve body is fully uncovered. As the cage moves the ball over the port, flow is restricted. When the ball is in position to close the port, the action of the cage forces the ball sideways into the circular discharge opening for tight shut-off. This valve has been used extensively as an on-off control for the blow-off from the bottom of the digester in pulp mills. Its flow characteristic is close to linear.

Baldwin SR-4® system controls mixing to .1% repeatability



In a west coast processing plant, liquid sugar is mixed automatically by a Baldwin SR-4 system whose accuracy is within .1% repeatability.

Here's how it works. A 2,500-gallon mixing tank and 10,000-gallon storage tank stand vertically on triangular frames whose corners rest on Baldwin SR-4 load cells (photo at right). These strain gage type cells measure tank weight changes and transmit electrical signals to a Baldwin indicator-controller (photo above) which shows total weight of tank contents in pounds.

To start the process, dry sugar and water valves are opened manually; from there on mixing is automatic. When the load cells signal that predetermined proportions have been reached, sugar and water flow are shut off by the indicator-controller.

Baldwin SR-4 systems can be developed for any application involving load, pressure, tension, torque or thrust. Custom-built systems range from simple weighing and measuring devices to complete feedback control. "Packaged" systems and component transducers are also available. For illustrated bulletins, write us at 806 Massachusetts Avenue, Cambridge, Massachusetts.

ELECTRONICS & INSTRUMENTATION DIVISION

BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Hamilton • Lima • Loewy-Hydropress • Madsen • Pelton • Standard Steel Works

For more information circle **58** on inquiry card.

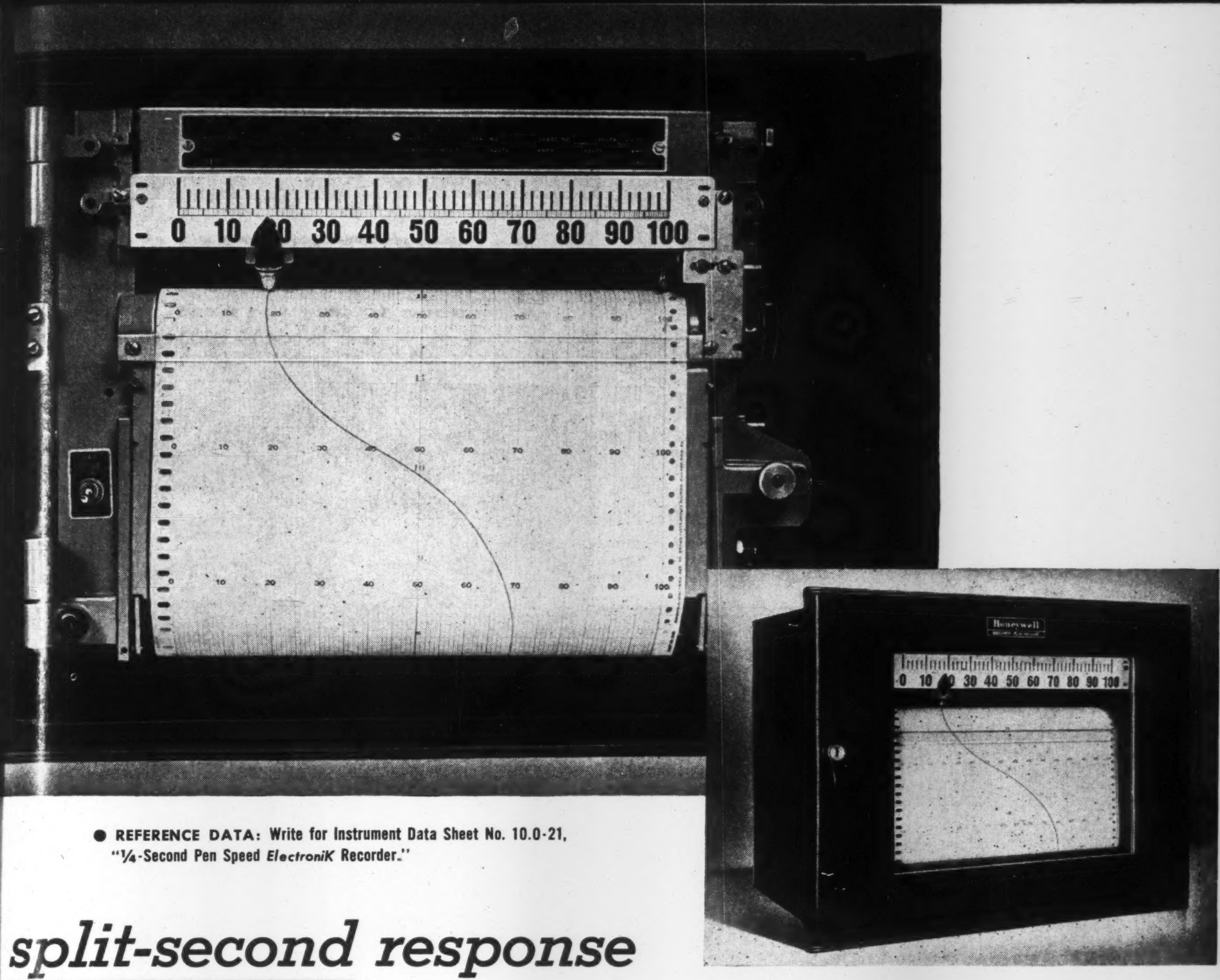
New ¼-second *Electronik* recorder

follows fast-changing variables with

Outstanding new features:

- Simplified design
- Improved damping
- High input impedance
- Continuous standardization

For more information circle **59** on inquiry card.



● **REFERENCE DATA: Write for Instrument Data Sheet No. 10.0-21, "¼-Second Pen Speed *ElectroniK* Recorder."**

split-second response

DESIGNED to meet the special data-recording requirements of experimental stations, laboratories, and research centers, the new ¼-Second Pen Speed *ElectroniK* Recorder fills an important gap between conventional large-chart recorders and oscillographic instruments.

This new *ElectroniK* Recorder is the *fastest* large-chart instrument available today . . . the perfect solution for high-speed plotting of any function that can be reduced to a d-c millivolt signal. It offers the investigator extreme sensitivity, complete flexibility, laboratory precision . . . the *basic* plus features of advanced Honeywell design. In addition, the recorder incorporates many *new* features the research man will appreciate:

Easy range change—All components of the potentiometer bridge are located on one bakelite card. To change the range, merely put in the appropriate card.

New design plug-in amplifier—has many times the power output of standard units . . . features high input impedance, easy accessibility, flexible gain control, and rugged construction.

New pen and carriage designs—prevent pen clogging and paper tearing. Ball point pen easily removed. Transparent cartridge gives visual indication of ink supply.

New slidewire and contacts—Designed for long life under high speed operation.

Your nearby Honeywell sales engineer will be glad to discuss ways in which you can benefit from the new ¼-Second *ElectroniK* Recorder in your research work. Give him a call . . . he's as near as your phone.

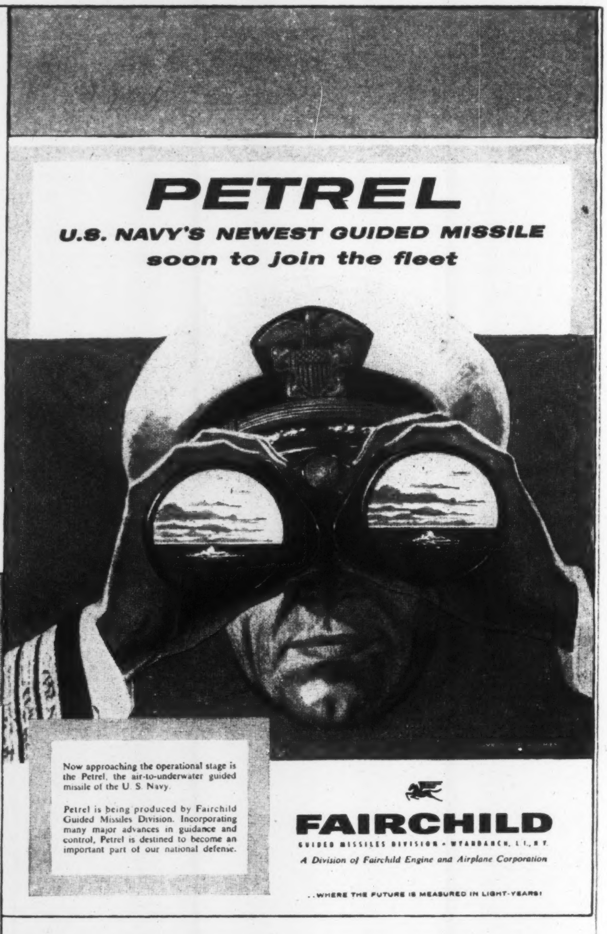
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

H
HONEYWELL

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

For more information circle **59** on inquiry card.

The PACE of Progress



PETREL

U.S. NAVY'S NEWEST GUIDED MISSILE soon to join the fleet

Now approaching the operational stage is the Petrel, the air-to-underwater guided missile of the U. S. Navy.

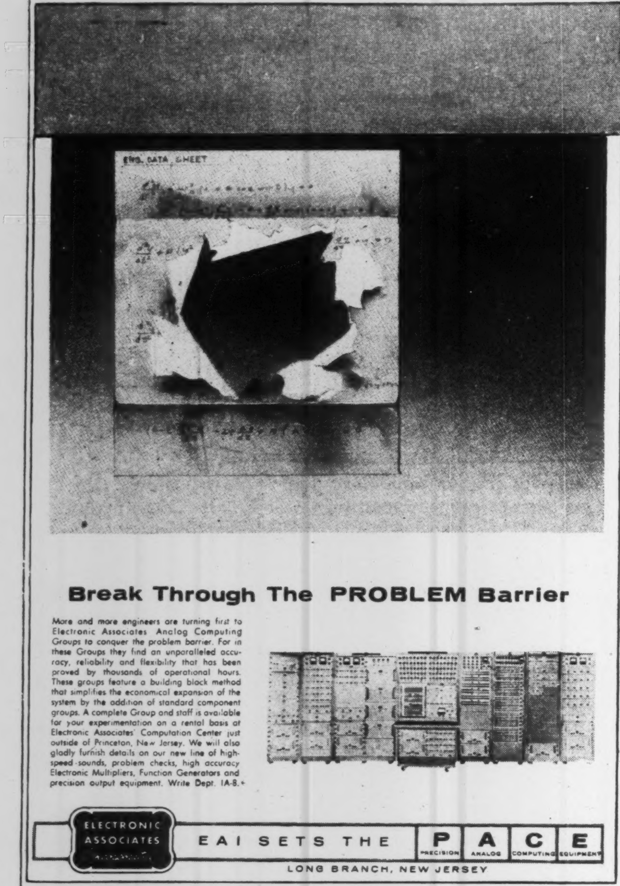
Petrel is being produced by Fairchild Guided Missiles Division. Incorporating many major advances in guidance and control, Petrel is destined to become an important part of our national defense.

FAIRCHILD

GUIDED MISSILES DIVISION • WYANDANCH, L.I., N.Y.

A Division of Fairchild Engine and Airplane Corporation

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!



Break Through The PROBLEM Barrier

More and more engineers are turning first to Electronic Associates Analog Computing Groups to conquer the problem barrier. For in these Groups they find an unparalleled accuracy, reliability and flexibility that has been proved by thousands of operational hours. These groups feature a building block method that simplifies the economical expansion of the system by the addition of standard component groups. A complete Group and staff is available for your experimentation on a rental basis at Electronic Associates' Computation Center just outside of Princeton, New Jersey. We will also gladly furnish details on our new line of high-speed sounds, problem checks, high accuracy Electronic Multipliers, Function Generators and precision output equipment. Write Dept. IA-8.

ELECTRONIC ASSOCIATES

EAI SETS THE P A C E
PRECISION ANALOG COMPUTING EQUIPMENT

LONG BRANCH, NEW JERSEY

Fairchild Guided Missiles Division, in Wyandanch, Long Island, New York selected EAI's Precision Analog Computing Equipment. Another example of two leading American Companies working together to break the problem barrier. Write Dept. IA-3 for details on the reliability, accuracy, and complete flexibility of EAI's PACE Equipment. We will also gladly furnish details on the rental of time and computing systems at the EAI Computation Center in Princeton, New Jersey.

Visit our booths which are Nos. 329, 331 and 333 at the IRE Show for the latest advancements in Analog Computing Equipment.

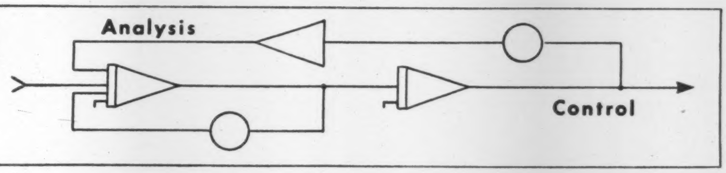
ELECTRONIC ASSOCIATES *Incorporated*

EAI SETS THE P A C E
PRECISION ANALOG COMPUTING EQUIPMENT

LONG BRANCH, NEW JERSEY

For more information circle **60** on inquiry card.

The SIMULATION COUNCIL *Newsletter*



John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

1891 West Chapel Drive
Camarillo, Calif.

Western Simulation Council
Bill L. Waddell, Giannini DATEX Division, Pasadena, Calif.; Chairman, Steering Committee

Midwestern Simulation Council
J. J. Stone, Battelle Memorial Institute, Columbus, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Frank Richmond, Glenn L. Martin Co., Baltimore, Md.; Chairman, Steering Committee

Southeastern Simulation Council
W. K. McGregor, ARO, Inc., Tullahoma, Tenn.; Chairman, Steering Committee.

Some week! Suzy and I drove night and day to get to Dallas in time to arrange for the four Simulation Councils' "reception"; got there a day early and got *snowed in*. Couldn't get our car out of the motel carport. Mushed down to corner store for steaks and drinking groceries, so day was well spent.

Interesting sessions at the National Simulation Conference next day, then the reception. Opened the bar promptly at eight, so only about 25 of the 150 some odd people present were able to hear representatives of the four Councils tell something of their local operations. Fun though. Saw most everyone I ever knew in the simulation field.

Another day of good sessions and a very interesting trip to Chance Vought and Convair that evening set the stage for the final day of the Conference, on which representatives of the Councils decided—but that's another story.

Anyway, some idea of the interest shown in the Conference is that some 200 people were still there to hear me talk about diode function generators as the *last* speaker on the program *Saturday afternoon!*

We then rounded out the big week of our visit to "Big D" by driving back to "Sunny California" in time to get back on the job and keep the Navy happy. I repeat, some week!

Bits

A good engineer is he who knows what he can neglect! Methinks the same may be said of editors. This month I have so much material that I must cut drastically, yet attempt to retain all items of interest. I have *Bernie Loveman's* notes on the Eastern Simulation Council's discussion of the use of digital computers for simulation; *Hal Coleman's* collection of résumés of the Midwestern Simulation Council's panel on patch panels; and *Bill Bradley's* writeup of the Southeastern Simulation Council's sessions at Georgia Tech. Any one of these is deserving of the major part of a *Newsletter*, but this month I must condense all three into one and still have enough space for some miscellaneous info and, of greatest interest to me, news of the formation of the National Simulation Council. And finally, I wouldn't be the man I hope you think I am if I let Panhandle Pete's remarks in the January *Instruments and Automation* pass without comment.

Pieces

MIDWESTERN SIMULATION COUNCIL

Instruments and Automation magazine (that's all that extra paper that constitutes the front and back covers of this *Newsletter*) was host to the Midwestern Simulation Council meeting in Chicago at the time of the Automation Show last 14 November. When your Editor expressed surprise at the large attendance (no count, but I would estimate more than 70) he was told this was not unusual at either the Midwestern or the Eastern meetings. Gee, the way these kids outgrow their parents! We probably average about 35 at the Western Simulation Council meetings.

The program was a panel discussion of patch panels in which representatives of computer manufacturers explained why they designed their panels the way they did, and one user told how he felt about it.

Sticking my neck out like the turtle I'll tell you what I got out of the meeting and Hal Coleman's résumés.*

Hussey on EASE Technique

Joe Hussey (Berkeley Scientific Div., Beckman Instruments, Richmond, Calif.), speaking for the EASE computer, discussed metal vs phenolic boards, a basic consideration. The metal boards facilitate shielding and the grounding of any leakage currents, but they constitute a shorting hazard. On the other hand, leakage currents might be troublesome with phenolic boards. Joe said they got around this by patch-board layout. Leakage between amplifier outputs is inconsequential because the outputs are low impedance. Cross-talk between amp grids does not occur because, as a result of feedback, all grids operate at essentially the same (ground) potential. The only danger then is that leakage may take place between outputs and grids. As this is in parallel with the feedback element, the effect is negligible in the case of summing and inverting amplifiers (where leakage resistance of the order of 10^6 megs may be in parallel with a feedback resistor of the order of one meg), but it may cause phase lead or cross-talk in the case of integrators. Therefore, Beckman designed their phenolic panel so that grids and outputs are not only some distance apart, but so that the plug-in input resistors form a barrier between them.

---

*Hal is with Bendix Research Laboratories, Detroit, Mich.

As a byproduct of designing so that shielding is not necessary, they are able to use "Add-a-plug" patch-cord plugs which "add a hole" as they use one, thus extending the capacity of the board without making it larger or more complex.

Thus, says Joe, an EASE user can "Have his cake and eat it too"—a neat trick!

Kennedy on PACE Technique

Jerry Kennedy (Electronic Associates) next presented the case for EA's aluminum patch panel. Briefly, they decided that patch-cord shielding was desirable and that leakage between terminals was important. As to the possibility of shorting, they argue that everything is fuzed so that no damage can be done. New operators might blow a few or a dozen fuzes at a nickel apiece, but they soon learn to plug only "cold" terminals (i.e., plug into energized holes with unenergized leads) when the computer is operating. This they say is a small price to pay for eliminating pick-up, cross-talk, and leakage.

Jerry also pointed out other advantages of the PACE system:

1. The patch-bay forms one wall of a thermostatically-controlled oven which holds the temperature of the passive computing elements at 100°F, ± 1°.

2. There are 1800 holes in a standard layout, which maximizes use of bottle plugs to connect adjacent computing elements.

3. Special layouts may be prescribed by the customer.

4. Bottle plugs are color-coded as to function and patch-cords as to length.

Morrill on GEDA Technique

Charlie Morrill (Goodyear Aircraft Corp., Akron, Ohio) next spoke of the general philosophy which guided the design of the GEDA patch panel. Stating that seldom is a good analyst a good synthesist, and vice versa, Charlie went on to say that no one kind of patch panel can be best for all kinds of work.

A computer designed with the "mathematical approach" has available the terminals of amplifiers which are "committed," i.e., prewired as summers, integrators, etc. This is straightforward, it makes the computer simple to use, and it is particularly appealing to the analyst who likes to express relationships mathematically.

Contrasted to this is the engineering or simulation approach, which leaves amplifiers uncommitted so that "input and feedback networks can be almost any size, real or complex, active or passive, linear or nonlinear." This facilitates using one or a small number of amplifiers to simulate each component of a system, then combining them in the same way that the actual components are combined. Such a synthesis appeals to the engineer, the gadgeteer, and the inventor, and the GEDA patchboard was designed with this in mind.

"The disadvantages," Charlie said, "are obvious: The size of the problem board, the appearance of the wired problem, greater setup time, and more training and experience required of the operator." The advantages, however, Charlie gave as: (1) More complete problem storage on the problem board; (2) more economical use of amplifiers, potentiometers, and other computing elements; (3) ability to solve problems that necessitate operational flexibility—that is, problems that *cannot* be solved unless network values may be freely chosen; and (4) clearer insight into the problem being studied than can be provided by a set of mathematical equations.

Charlie proceeded to illustrate his points with examples taken from Goodyear Engineering Reports*. Before closing he returned briefly to the subject of metal vs. phenolic patch panels to point out that though leakage is the largest source of error, it is capacitor not panel leakage.

Edwards on Mid-Century Technique

Jim Edwards next described the patch panel for the Mid-Century computer (Mid-Century Instrumatic Corp., New York, N.Y.) Like EA, they too use an aluminum board, but unlike EA they have found that shielding of patch-cords is not necessary. They report no detectable cross-talk at frequencies up to 400 cps.

As the Mid-Century patch bay is identical to their prepatch board, it is possible to use the computer without the board. Another novel feature of their computer is that they use a motor-driven gear arrangement to provide a 5/16" wiping action of the 800 contacts as it positions the board.

Jim agreed with Charlie that optimum panel layout is a matter of the type of problem most often encountered, and described the Mid-Century design as a compromise which can be modified if desired.

Loveman on REAC Technique

Bernie Loveman (Reeves Instrument Corp., New York, N. Y.) described the REAC patch-board system, which uses 1, 2, 4, or 6 Remington-Rand boards having 816 connections each. "The advantages of using these standard patchboards are reliability, flexibility, low cost, and ease of use," Bernie said.

The removable board supports and locates the patch-cord plugs, which protrude and contact springs on the fixed board to produce a wiping action as a cam mechanism locks the portable board in place. It is not necessary to remove the portable board or to switch voltages off the computer to insert or remove patch cords. An interlock switch is provided to remove all voltages from the fixed patch bay when the portable board is removed for changing problems.

Not all holes on the Rem-Rand are used, because the patch-cords would be too close together for convenience. A mask carrying the terminal designations is placed over each panel so that only the jacks used are visible. This permits the design of a convenient layout with a non-uniform distribution of jacks which allows one to memorize the computer layout in short time.

---

*Some, illustrating the effective use of analog computers, are available on request to Goodyear Aircraft Corp., Akron 15, Ohio

Special plugs have been designed to expedite patching. These include: (1) Jumper plugs to connect adjacent terminals, (2) line multiples, (3) four types of patch plugs to interconnect either a diode multiplier or a dc resolver with inverters (the inverters are available for general use when not required with the multiplier or resolver), and (4) dummy plugs to be used when a patch-cord is removed to be reinserted later. These have a hole in the back for the patch cord and, because they protrude from the patch board, they serve as reminders of any change.

To eliminate surface leakage, grounded conducting grids are silkscreened on the portable and the fixed patch boards. A plastic mask covers the grid and prevents shorts to ground when the operator makes changes with the patch board on the computer.

Stone on the Users' Point of View

Jim Stone (Battelle Memorial Institute, Columbus, Ohio) presented the user's point of view. By way of background he traced the development of patching from the original prewired special-purpose computer to the present very flexible system.

From the user's standpoint prepatch panels must satisfy requirements of durability, operability, and reliability. The requirements for durability and reliability are rather obvious, but Jim explained operability in more detail. Some factors to be considered, he said, include:

(1) Impedance and amplifier connections should be arranged in a manner that simplifies the connections of standard circuit configurations.

(2) The panel should provide for the connection of nonstandard circuit configurations without undue difficulty.

(3) Panel markings, so far as possible, should be self-explanatory.

(4) A problem as patched should appear as simple as possible to ease the task of circuit checking and, at a later date, circuit modifications.

(5) Where possible, bus connections and other plug wire reduction features should be incorporated to reduce the apparent complexity of a problem when connected by plug wires in the patch panel.

Jim concluded his remarks with a very good point which is often overlooked. The user bears a *responsibility* to provide feedback to machine manufacturers to enable them to design the kind of equipment he needs.

SIMULATION COUNCIL

EASTERN SIMULATION COUNCIL

(from Bernie Loveman's notes)

Forty-five representatives of 18 different organizations attended the 21 November meeting of the Eastern Simulation Council at Massachusetts Institute of Technology to discuss "The Use of Digital Computers for Solving Simulation Problems" and to join their host, *Dr. W. W. Seifert*, in an interesting tour of the MIT Whirlwind Computer.

Steeg on Use of Digital Computers at DACL

Dr. Carl Steeg began the technical discussions by telling about the use of digital computation at the Dynamic Analysis and Control Laboratory, MIT, and describing three types of problems for which both analog and digital computers may be used:

(1) Analysis—This includes check solutions for analog computers and the solution of numerical problems.

(2) Synthesis—This includes optimization of parameters and studies of sampled data systems.

(3) Control—i.e., physical simulation.

Several reasons for the increased use of digital computers at DACL include: (1) A better understanding by digital and analog personnel of the problems that they have in common, (2) improvements in digital computers, particularly in high-speed memories, and (3) improvements in internal programming—i.e., interpretive subroutines.

Dr. Steeg described a problem involving 20 to 25 ordinary nonlinear differential equations which had been solved on both the analog computer at DACL and on a digital computer (Whirlwind 1, a one-address machine with 1024 words of magnetic-core memory plus magnetic-drum and tape memories). Some comparative data are:

	ANALOG	DIGITAL
Programming time	(not given)	3 days
Solution time	12 seconds	40 minutes
Cost	1500 solutions for $20,000	10 solutions for $750

Rubinoff on Moore School Applications

Dr. Morris Rubinoff (Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia) described a digital computer which operates in real time and is to be used in conjunction with a cockpit as a universal digital operational flight trainer (UDOFT). The computer is required to solve 18 simultaneous ordinary nonlinear differential equations.

The advantages of using digital computation include controllable precision and accuracy; flexibility which allows one to change airplane types conveniently and quickly; and versatility, which permits multicockpit operation using one digital computer.

"Restraining influences" in the use of digital computers are the cost, the time required for program preparation, and computer "blunders"—i.e., intermittent random failures.

To indicate new trends, Dr. Rubinoff described a transistorized computer being designed. This unit will have 8000 20-bit words of magnetic-core memory, will occupy three to four cubic feet, will consume about 1000 watts, and will cost approximately $150,000.* Addition time will be 3 microseconds, and the multiplication of two 20-bit words will take 55 to 60 microseconds.

Weinberger on NBS Applications

Arnold Weinberger (National Bureau of Standards, Washington, DC) next told about a study to determine the feasibility of using digital techniques for a tactical trainer. The system to be simulated consists of 30 ships, fifteen of which, at the instructor's option, can be controlled by the student, while the instructor has at his disposal 70 aircraft.

The computations required include the dynamic and kinematic motion of the ships, kinematics of the aircraft, and synthetic radar displays. A major problem was the handling of the large quantity of input and output data in real time. A complete cycle for all computations had to be completed in less than two seconds.

The study showed that the amount of computation required was such that no available commercial computer could keep up with the computation required. However, the UDOFT described by Dr. Rubinoff would be adequate for such a tactical simulator.

---

*A bargain; only about 0.1 the price of the same volume of pure gold!

SIMULATION COUNCIL

SOUTHEASTERN SIMULATION COUNCIL

(from William Bradley's notes)

Representatives of 21 organizations gathered at the Georgia Institute of Technology in Atlanta on the morning of 28 November for the second meeting of the Southeastern Simulation Council. *M. D. Prince* (Engineering Experiment Station, Georgia Tech) opened the meeting with a brief talk on the facilities and functions of the Engineering Experiment Station; then his colleague *Searcy Hollis* described a special-purpose computer for simulation of the radiation field produced by aperture-type microwave antennas. As antennas are over our heads (no pun intended) we hasten to change the subject to something we understand, namely *Chalmer Jones'* (Heath Company, Benton Harbor, Mich.) talk on the functional considerations for a low-cost analog computer. However, as we have covered Chal's baby in these columns previously, we will only pause to comment that the low price (approximately $700 for 15 amplifiers) and student labor for assembly should make it attractive to educational institutions.

The next speaker, *O. J. Sullivan* (Chance Vought Aircraft, Dallas, Tex.) presented a paper on simulation techniques as applied to aircraft and missiles where they can be used to evaluate new design features of system components without actually building the equipment.

After an intermission *Harold Valery* (Lockheed Aircraft Corp., Marietta, Ga.) outlined a training course on dynamics and the synthesis of closed-loop servo systems being offered to Lockheed personnel, and gave a detailed description of the various methods employed to simulate flight conditions on mock-ups, which he illustrated with slides.

Dr. Mario J. Goglia (Mechanical Engineering Dept., Georgia Tech) next presented a problem on two-phase fluid flow between the tanks and fuel pump of jet aircraft. The fuel (JP4) is very complex and has a tendency to absorb air under certain conditions, thus adding to the difficulty of the problem.

W. K. McGregor (ARO, Inc., Tullahoma, Tenn.) expressed doubts as to whether this problem could be solved by analog simulation methods, but noted that one purpose of the meeting was to point out the nature of the problems encountered.

Fred Dixon (Engineering Experiment Station) concluded the morning session by discussing briefly uses of analog computers in defense research, and suggesting some applications for industry. (!)

* * *

Opening the afternoon session (a joint meeting of the Simulation Council and the Georgia Tech Mathematics Colloquium) Mr. Prince introduced *Dr. John W. Cell* (Mathematics Department, North Carolina State College), who spoke on mathematical problems in connection with spinner rocket simulation studies, and showed slides. A solution which might easily have been overlooked by any point increment technique was obtained. Dr. Cell had five graduate students working with him on the project, and recommends it as an excellent way of training computer engineers.

* * *

More was said on the subject of training at the evening session (when these fellows have a meeting they make a day of it!) at which Dr. Cell moderated a panel discussion on the training and education of computer engineers. The purpose was to bring together educators and representatives of industry to discuss what is being done and should be done to increase the quality and quantity of trained computer engineers.

Dr. Bertram M. Drucker (Mathematics Dept., Georgia Tech) outlined courses on the programming of digital computers which recently have been offered by the Mathematics Department at Georgia Tech as a result of the new digital computer facility (Rich Electronic Computer Center) which was opened at Tech last year. No mathematics course in analog computer theory is planned as yet. (!)

Dr. Drucker had some pertinent questions for industry: How essential is the actual equipment in training the computer engineer? How far should the schools carry the training? Should the schools train programmers and numerical analysts, or should that be left up to industry?

Dr. Frank O. Nottingham (Electrical Engineering Dept., Georgia Tech) described the three courses at the M.S. level offered by his Department. At present a small analog computer, built by graduate students, is used to simulate control system response as part of this series.

Dr. E. K. Ritter (Engineering Experiment Station, Georgia Tech) recognized the need for the engineer to get more mathematics, but pointed out that the problem of getting and keeping qualified teachers is becoming acute. He proposed that industry lend some of their theoreticians to the schools, which should benefit industry in the form of higher-quality students.

Dr. Drucker observed that a lot of time and teachers were being wasted reteaching high-school mathematics to freshmen in college, and Dr. Cell said that this may get worse since the colleges are having to hire away the best high-school mathematics teachers to replace those college teachers who are being hired by industry!

H. A. Corriher, Jr. (Engineering Experiment Station, Georgia Tech), asking what should be dropped from the curriculum so that the student will have time to take the suggested new computer courses, said he favors putting less emphasis on long involved lab reports and allowing the student more time for theory. Also, some of the hours spent mastering such subjects as thermodynamics, mechanical drawing, and mechanics could be saved if survey courses were substituted.

Mr. Prince suggested that an electrical engineering student taking the electronics option should be allowed to substitute some courses in feedback and servo theory for the classical power machinery and distribution series.

O. J. Sullivan (Chance Vought Aircraft, Dallas, Tex.) said that the size of the installation makes a lot of difference in the qualifications an engineer should have. Small units only need one man; however, he must be mathematician, programmer, and technician all rolled into one. A solution might be to evolve a separate course for computer engineers so they could be versed in both digital and analog technology.

C. P. Moore (Lockheed Aircraft Corp., Marietta, Ga.) pointed out that the degree of sophistication with which computer mathematics are employed frequently make a B.S. matheamtics background inadequate. The computer engineer should be well grounded in engineering physics from the mathematical standpoint, and for the M.S. student Mr. Moore recommends extensive higher mathematics.

Sam Robinson (Lockheed Aircraft Corp., Marietta, Ga.) added that the differential equations courses should be re-evaluated in the light of analog-computer techniques. There should be less emphasis on the trick solution and more on the basic practical methods.

F. T. Shaver (Redstone Arsenal, Huntsville, Ala.) agreed that a good computer course should not attempt to make the engineer an expert in all the fields but should cover computer theory and circuits, so a man with a B.S. degree could learn the techniques of computing after he gets into the field.

W. G. Fort (Union Carbide, Oak Ridge, Tenn.) also stressed that if a new graduate is thoroughly grounded in theory he can soon pick up the proper techniques.

Dr. Cell then summarized the group's findings, pointing out that almost everyone had advocated more concentration on the basic applied mathematics and physics. He further agreed that many of the standard courses need re-evaluation in the light of new concepts of digital and analog simulation.

INFORMATION (Without Theory)

Most interesting piece of info* to me was that representatives of the four Simulation Councils got together in Dallas and decided there should be some sort of National Simulation Council. I had discussed the idea privately with a few friends and thought we decided against it on the grounds that it would accomplish nothing toward the original objective of the Councils, to wit: the informal discussion of half-baked ideas at the working level.

Events of those days in Dallas changed my attitude, however, so perhaps I can guess what motivated this action by the other representatives:

(1) The success of the National Simulation Conference clearly indicated the desirability of such an annual meeting. Since the Bureau of Aeronautics quit sponsoring the Cyclone and Typhoon symposia, and since the Dallas meeting was not intended to be annual affair, many felt that some action should be taken to assure future meetings. A National Simulation Council could stimulate interest in such an annual conference.

(2) The National Simulation Conference and the Simulation Councils' "reception" pointed the way for future collaboration wherein nationally-established technical societies can handle the selection and presentation of formal papers, and the Simulation Councils can handle the informal and social events—a beautiful symbiotic relationship!

I'm for it!

The Publications Committee of the Professional Group on Electronic Computers (PGEC) of the IRE would very much like to include more material on analog computers in the publication, TRANSACTIONS OF THE PGEC.

The Publications Committee feels that the TRANSACTIONS can be used as a medium for formal publication of papers which may be presented informally at Simulation Council meetings and which may be worth expanding for wider dissemination.

The PGEC plans to have the issue published in September 1956 devoted to analog computer check methods, and tie-ins of digital computers, or digital techniques, with analog computation. Papers for this issue should be sent to Prof. R. E. Meagher, Editor of the TRANSACTIONS ON ELECTRONIC COMPUTERS, at 168 Eng. Res. Lab., University of Illinois, Urbana, Illinois.

* * *

Enjoyed hearing from our friend *Elmore Blanton* (who arranged the physical simulation session at the Conference) about his joining Hycon Eastern. This new partially-owned subsidiary of Hycon Manufacturing Company, which is going in for telecommunication systems, data handling and processing, and production of specially-designed instruments, sounds very interesting.

Thots

The thought for the month was suggested by Stan Rogers. Noting the increase in the use of digital differential analyzers, the special techniques required for their effective use, and the comparatively few people who are familiar with them, Stan draws a parallel with the state of the simulation art when the first Simulation Council was formed in November 1952, so "Why not a DDA Council, so we can pool our ignorance." If you have any ideas on the subject write Stan at Electronics and Engineering Laboratories, Building 51, Plant 1, Convair, San Diego 12, California.

* * *

And as for "Panhandle Pete", howdoyalike that guy? In the January '56 issue of ***Instruments and Automation*** he refers to my picture in the April issue (above) and says, among other

things, "Look at him! Scared to death, a bashful man clinging to his wife's hand like a man clutching his last drink before the bar closes!" Well Pete, you got the general idea, but you're as fuzzy on the details as a caterpillar on a peach! I *was* clinging to Suzy's hand, and it *did* have to do with a bar. And I *was* scared. I was scared if I let go I would fall down before I could get back to the bar. Man, that picture was taken in New Orleans during Mardi Gras week!!

Computer Events

Other events on page 430

Eastern Simulation Council

Date: March 23, 1956
Place: Waldorf-Astoria Hotel—New York City
Host: Mid-Century Instrumatic
Subject: Function Generation

Symposium for Management on Applications of Analog Computers

Dates: April 10-11, 1956
Place: University of Kansas City, Kansas City, Missouri
For information write Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Missouri

Western Simulation Council

Date: May 10, 1956
Place: Aerojet-General Corp., Azusa, Calif.
Time: 1:00 PM
Subject: Computer Consoles
Confidential clearance will probably be required for the tour. For further information write Norman Irvine at Aerojet.

Midwestern Simulation Council

Date: May 15, 1956
Place: Battelle Memorial Institute, Columbus, Ohio. For information write J. J. Stone at the Institute.

---

*See editorial on page 459.

New

TRANSISTORIZED MINIATURIZED

TYPE 2007T

FREQUENCY STAN
TYPE 2007T SER
FREQUENCY
MADE BY
AMERICAN TIME PRODS. INC
NEW YORK, N.Y.
LICENSED UNDER U.S. PATE
WESTERN ELECTRIC

400 CYCLES ±.02%

28 VOLTS D.C.

SPECIFICATIONS

INPUT
20 to 35V DC
at approx. 5 m.a.

OUTPUT FREQUENCY
400 or 500 cycles
Type 2007T
+ —.02% from —65° to + 85°C.
Type R2007T
+ —.002% from + 15° to + 85°C.
Type W2007T
+ —.005% from —65° to + 85°C.

OUTPUT VOLTAGE
5 volts, sine wave.
Substantially uniform
from —65° to + 85°C.

LIFE EXPECTANCY
several times that of vacuum tubes

INTERNALLY SHOCK MOUNTED
on Silastic

MAGNETICALLY SHIELDED

HERMETICALLY SEALED

OCTAL BASE

SIZE
4½" x 1½" diameter

WEIGHT
7 ounces

COMPLETE INFORMATION ON REQUEST
PLEASE SPECIFY TYPE 2007T

Precision FREQUENCY STANDARDS

These units, which are the result of several years of development and testing, offer a new standard of simplicity and reliability. Particularly noteworthy is the uniformity of output signal voltage with temperature change. Small size and light weight make them ideal for airborne and portable use.

For applications where only higher B voltages are available, a simple voltage reducing circuit may be used.

American Time Products, Inc.

580 Fifth Avenue ***New York 36, N. Y.***

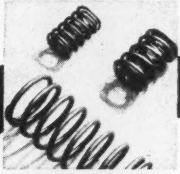
MANUFACTURING UNDER PATENTS OF WESTERN ELECTRIC COMPANY

For more information circle 61 on inquiry card.

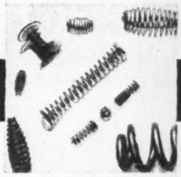
60 second tour

shows it in a nutshell . . .

All-Inclusive Spring Service

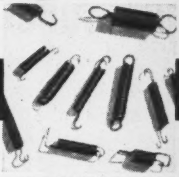


COMPRESSION SPRINGS
Regular, Double



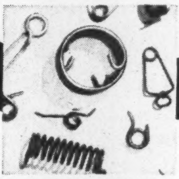
COMPRESSION SPRINGS
Special Shapes
Variable pitch

VOLUTE SPRINGS
Coned end

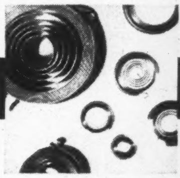


EXTENSION SPRINGS
Special Hooks
and Loops

EXTENSION SPRINGS
Swivel End
Drawbar



TORSION SPRINGS
Single, double
Edge wound

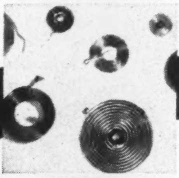


POWER SPRINGS
Clock or Motor

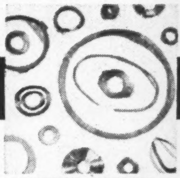
FLAT SPRINGS
Arched, Curved-beam
Elliptical

**CLIPS, CLAMPS
and COLLARS**

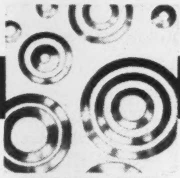
**FASTENERS and
RETAINERS**



HAIRSPRINGS
for Instruments
Gauges, etc.

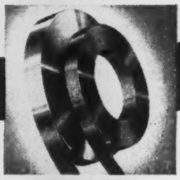


SPRING WASHERS
Wavy, Star, Finger,
Expander, etc.



BELLEVILLE SPRINGS
In Series, Parallel
Parallel-series

DIAPHRAGMS
Discs, Plates



PLUS
**COLD-ROLLED
SPRING STEEL**

DIVISIONS OF
**ASSOCIATED
SPRING**
CORPORATION

COAST TO COAST

**WALLACE
BARNES
COMPANY**
BRISTOL,
CONNECTICUT

**THE WILLIAM
D.GIBSON
COMPANY**
1800 CLYBOURN AVE.
CHICAGO 14,

**RAYMOND
Manufacturing
COMPANY**
CORRY,
PENNSYLVANIA

**BARNES-
GIBSON -
RAYMOND**
40300 PLYMOUTH RD.
PLYMOUTH, MICH.

**B·G·R
COOK
PLANT**
ANN ARBOR
MICHIGAN

**SEABOARD
Coil Spring Div.**
15001 S. BROADWAY
GARDENA, CALIF.

**OHIO
DIVISION**
1825 EAST FIRST ST.
DAYTON, OHIO

**WALLACE BARNES
COMPANY**
STATE FAIR BLVD.
SYRACUSE 9 (Solvay), N.Y.

**MILWAUKEE
DIVISION**
341 E. ERIE ST.
MILWAUKEE, WIS.

**DUNBAR
BROTHERS
COMPANY**
BRISTOL, CONN.

**F. H. MANROSS
AND SONS CO.**
BRISTOL
CONNECTICUT

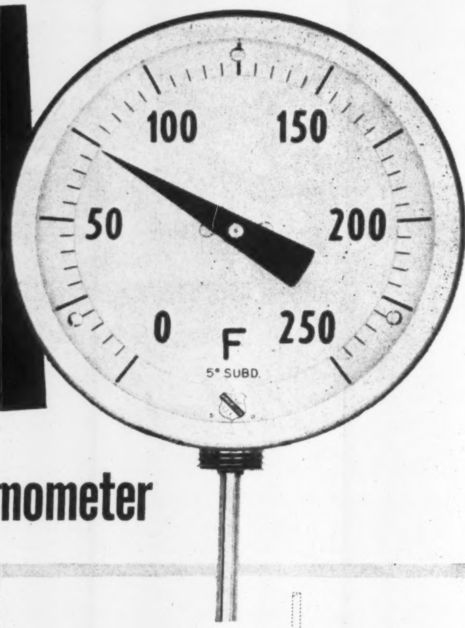
**THE
WALLACE BARNES
CO., LTD.**
HAMILTON
CANADA

Divisions of

ASSOCIATED SPRING CORPORATION

For more information circle **62** on inquiry card.

"Every Angle" Design
Maxivision® Accuracy
Bi-Metal Actuation



Now...all 3 in one 'American' Thermometer

Only this new American Thermometer* gives you the three features most demanded in a dial thermometer. The "Every Angle" design allows you to install this thermometer *anywhere* . . . then angle it in the direction that provides easiest reading. The anti-parallax Maxivision dial guarantees the surest, sharpest, easiest reading. Graduations are carried on a raised ring, set close to the cover glass, with an index-type, functional pointer set at the same level. The result — no perspective effect — parallax error practically eliminated. Finally, bi-metal actuation insures high sensitivity, economy, and surety of operation.

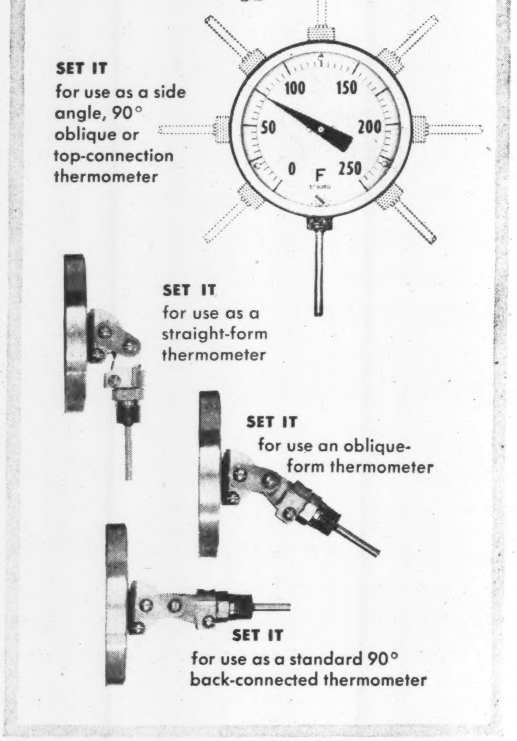
Install the new American "Every Angle" Bi-Metal Dial Thermometer anywhere — inside or out. Its climate-proof case defies any weather condition. The full use of these thermometers in any process plant makes possible temperature readings with the same ease and facility of those of a pressure gauge. Write today for complete information. Ask for Bulletin 148.

*Pat. App. For

SPECIFICATIONS

5-Inch Type 5-6060 American "Every Angle" Bi-Metal Dial Thermometer

Temperature Ranges: From minus 80° to plus 1000° F. Accuracy within 1% of range. *Dial Size:* 5". Scale approximately 10½" long. *Bi-Metal Coil:* Low mass, with single helix close to inside wall of stem assures high sensitivity. Silicone fluid dampens vibration, accelerates transfer, speeds response. *Case:* Stainless steel. *Bezel:* Threaded to case. *Front:* Clear, extra-heavy glass set in channeled gasket to seal case. *Pointer:* Functional type, adjustable from front. *Stem:* Lengths — 4" to 24", 18-8 stainless steel. All joints welded. *Connection:* Fixed, ½" NPT. *Separable Sockets:* Available in all materials and sizes normally required.



SET IT for use as a side angle, 90° oblique or top-connection thermometer

SET IT for use as a straight-form thermometer

SET IT for use an oblique-form thermometer

SET IT for use as a standard 90° back-connected thermometer

1850 AMERICAN U.S.A.

PHONE your Industrial Supply Distributor for experienced attention to your needs. He is always ready to help you ward off costly shut-downs through fast delivery from local stocks.

AMERICAN INDUSTRIAL INSTRUMENTS

MAXWELL MANNING MM&M & MOORE INC. TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICU

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFET RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mic*

For more information circle **63** on inquiry card.

Journal of the SCMA...

SOUTHERN CALIFORNIA METER ASSOCIATION

President: *Glen G. Gallagher*
Vice-President: *Philip Ver Planck, Jr.*
Auditor: *Earl W. Kramer*
Program Chairman: *Richard M. Voils, Jr.*
Secretary-Treasurer: *Geo. H. Forster, Jr.*, 640 Fillmore St., Fillmore, Calif.

Maintenance of MERCURY-TYPE METERS

Tips and suggestions regarding the servicing and maintenance of mercury-type differential-pressure flowmeters.

FRANK D. WELCH
General Petroleum Corporation

THERE are two general types of maintenance: "in-service maintenance" and "out-of-service or shop maintenance." The dividing line between the two may be perogative of the maintenance man, or may be governed by departmental or company policy.

The Differential-Pressure Body

The measuring unit of the differential-pressure instrument is composed of two chambers, commonly referred to as the *float chamber* and the *range tube*. They are connected together by a U-tube. Two common types are shown in Figs. 1 and 2.

Note the difference in the positions of the range tubes: In Fig. 1 the range tube extends below the float chamber; in Fig. 2 above the float chamber. In both the float chamber houses a float, float arm, and float shaft to which a recording pen is affixed.

The two chambers are referred to also as the *high-pressure chamber and low-pressure chamber*. In Fig. 1 the float chamber is the low-pressure side; in Fig. 2 the reverse is true.

When mercury is placed in the meter and the float has assumed its natural position, the pen is at zero position on the chart. When a difference of pressure is imposed on the instrument, the mercury levels and the float assume a position corresponding to the degree of pressure difference, usually expressed in inches of water. The pen indicates this change. In Fig. 1 the float rises as a differential in pressure is applied: in Fig. 2 the float falls.

Meter Installation

From a maintenance and service standpoint a meter should be installed as free as possible from vibrations: it must be level and as close to the orifice as is practical.

The connecting piping should have a valve on the high- and low-pressure lines. There should be a bypass line with the necessary valve or valves, and a vent valve. In field servicing it is sometimes advisable to have a vent valve on both the high- and low-pressure side. All valves should be easily accessible from the front of the instrument, and within easy reach of the serviceman. As to a specific manifold design, each manufacturer has recommendations for a specific service.

April Meeting: *Wednesday, the 19th, Rio Hondo Country Club, Downey, Calif.*
Feature: *Mr. J. R. Wilson will present a paper on "Recent Developments in Small Orifice Meter Runs —2" and Under"*

"In Service" Maintenance

Tips for servicing an instrument in the field can only be rather general in nature because each installation may have specific problems. The service requirements depend on historical data or experience. Scheduled periodic checking is often the rule and is certainly advisable. Instruments enduring severe service relating to contaminants require more frequent attention. *Whenever an instrument is serviced, the servicing should be thorough and complete.*

The first step in checking a meter is to close *one* of the block or line valves: then open the bypass. Observe the pen as it goes to or near the zero point on the chart. If the pressure-tight bearing is free, the pen will fall freely; if not, it will fall slowly.

After the pen has stopped moving, rotate the chart in its normal direction a bit. If the pen changes position it indicates too much pen drag. This can be remedied by bending the pen-arm to ease the tension. The pen should now rest on zero.

If the pen acts slowly when falling to zero, the pressure-tight bearing must be lubricated. (This does not pertain to the newer Teflon-type bearings.)

Ranging the Instrument

After the bearing has been lubricated the instrument can be "ranged." To range an instrument is to simulate full-scale flow by creating sufficient differential pressure. If the instrument is in a gas service this can be done by closing the line valves, opening the bypass valves, and venting the instrument to atmospheric pressure. Then

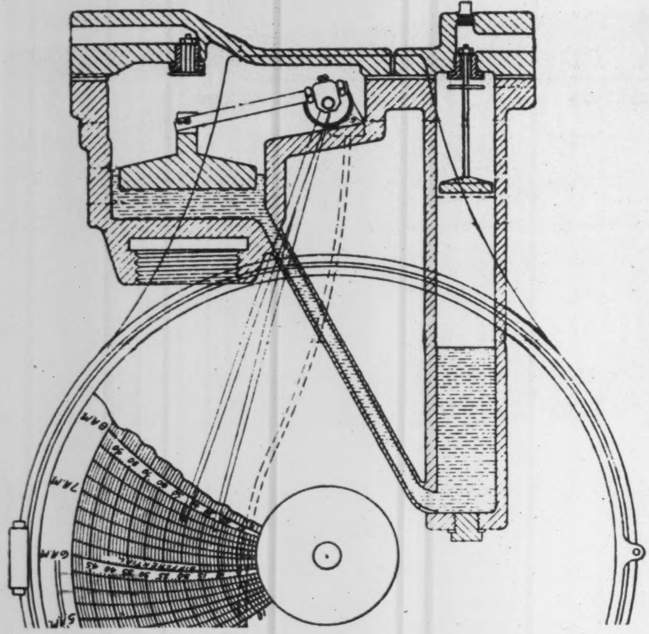


Fig. 1. Float in this type flowmeter is in low-pressure chamber. Other leg (range tube) of U-tube is interchangeable, whereby range can be varied (smaller diameter in range tube requires greater pressure in fixed chamber for equal float movements because float level does not change as rapidly as range-tube level.)

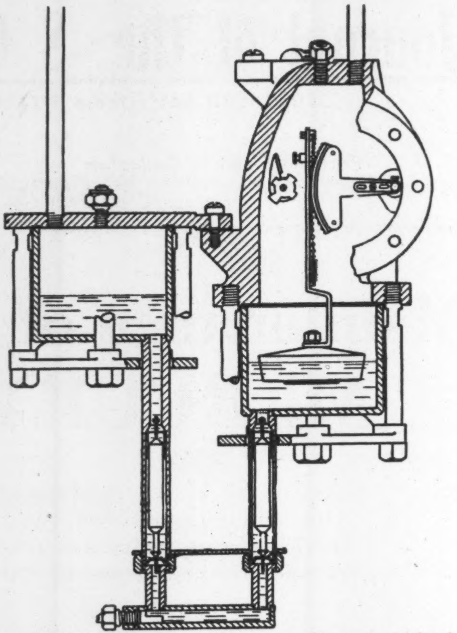


Fig. 2. Raised range tube puts float into high-pressure chamber, insuring maximum freedom from ambient temperature effects. Net error from expansion of mercury and decrease in density is *difference* of two values in high-pressure chamber, *sum* in low-pressure chamber, resulting in decreased temperature effect when float is in high-pressure chamber.

attach an aspirator to the high-pressure side and pump in sufficient air to cause the instrument to travel full scale. If this method is used, it is prudent to attach a manometer and check the calibration.

Leak Check

If the aspirator is not used the following method will do the job (except that there will be no calibration check) for both liquid-service as well as gas-service meters. In the first instance, we will suppose the instrument to be in gas service at sufficient pressure above atmospheric pressure to range the meter. With the high-pressure valve to the meter open, close the low-pressure valve and open the bypass; the pen goes to zero. Close the bypass valve and observe the pen for a short time. Movement of the pen indicates a leak on the low-pressure side. This should be repaired before proceeding. If the pen remains on zero, proceed by venting the low-pressure side; this must be done slowly and with caution so as not to blow the mercury out of the chamber. When the pen is at full range, close the block valve on the high-pressure side. Then pen should remain at full scale; if it starts to return to zero, it indicates a leak on the high-pressure side. A common method for locating the leak is to use liquid soap or other chemicals developed for this purpose.

Pen Drag Check

After the pen has come to rest the chart should then be advanced a bit to check for pen drag. Only rarely does the pen have proper pressure at zero and too much at the outer reading. However, if the pen goes above the chart the chart should be removed to check and make sure that the chart drive (clock) hub is not protruding too far through the chart plate, as might have resulted from a previous clock change.

Arm Length Check

The *arc* of the pen should also be observed at this time. If the pen is below the starting time arc when at full scale, the pen arm needs lengthening; if above th time arc it needs shortening. If the pen cannot be made to follow the time arc, the bearing shaft is bent. This usually requires replacement as directed by shop policy.

Mercury Check

The sufficiency of mercury can now be determined. I the meter is the type shown in Fig. 2, vent the low-pressure side enough to exceed the maximum chart scale: this indicates that the float is not resting on the bottom of the float chamber. (This could have been done wher "ranging" the meter.) If the instrument is of the typ shown in Fig. 1, it must be zeroed and the high-pressur side cautiously vented to force the pen below zero; thi shows that at zero the float was not resting on th bottom of the chamber. *It must be emphasized that venting the instrument to cause pen deflection must be don with extreme caution at all times.*

The preceding procedure also applies to liquid-fille instruments, except that leaks are detectable by visua observation without manipulation of valves or zeroing

The "ranging" described was for an instrument wit line pressure above ambient. If the line is in vacuum service, the procedure differs in one respect: The venting i on the high-pressure instead of the low-pressure side.

Blowing Out Lines

After these checks have been completed, the lines ma be blown out using line pressure. The purpose of this is t remove solids tending to lodge in the lines. The instrument may now be returned to flow service with but on check left.

Final Check

After the instrument is recording a flow, gently vent the low-pressure side (or high-pressure in vacuum service) to cause the pen to move only a line or so; if the pen returns immediately the meter can be assumed to be in good condition. If not, the trouble can be a number of things—dirty chambers, contaminated mercury, etc. The meter then should be cleaned or overhauled. The preceding final checks may seem to be superfluous, but they are justifiable and become easy with practice.

Visual observation of the external condition of the meter, and of the general condition of meter manifold, valves, and connecting piping is also required.

Most differential gages in gas service are equipped with a pressure-recording pen. The only practical method of checking it is to install a pressure gage of known accuracy for comparison. The recording pen should be checked at not less than three places—at line pressure, at zero gage-pressure, and at an intermediate pressure. Light tapping on the chart or slight chart movement checks for pen drag. The speed of pen response will indicate any plugging present in the capillary or Bourdon. Clearance between the pressure pen and the flow pen should be noted, not only at the pen but also along the pen arm, particularly if any change in pen drag has been made.

Shop Maintenance

The overhaul of a differential-pressure gage requires a complete break-down of the meter. The first step is usually to drain the mercury, after which the disassembly can be accomplished. The more fragile parts should be set aside to prevent damage. *Do not do anything to change a calibration adjustment.*

When the screws clamping the pen arm and the float to the bearing shaft are loosened, caution must be exercised to prevent bending the bearing shaft. Both instruments illustrated have separations in the U-tube. A bar of some sort may be inserted between the two legs extending below the chambers and just above the nut to counteract the force applied to the nut when loosening it.

Cleaning

After stripping the meter, the instrument is cleaned. The external surfaces can be sand-blasted or buffed to remove loose scale and rust and to prepare the surface for a protective coating or compound. Instruments subject to severe ambient conditions justify the use of primers followed by finishing coatings.

Gaskets and threaded surfaces are not generally recommended to be sand-blasted. The same usually applies to mercury chambers. This does not apply to sandblasting in the hands of an expert whose experience may enable him to control his cleaning.

The mercury chambers and float are probably the most important parts in cleaning, particularly if they have been subject to contaminated mercury. After these parts have been cleaned, it is advisable to place the float in an open container with clean mercury. Slowly raise and lower the float, observing the meniscus around the edges of the float. If the mercury tends to cling to the float while it is being raised, there is contamination. If it is severe, even after cleaning, it is advisable to fill each chamber of the meter with mercury and slowly drain while observing the walls of the chamber for contamination. *All surfaces contacted by mercury must be thoroughly clean, otherwise the overhaul is worthless.*

When assembling the instrument, use a good thread antiseizure compound on threads. Most products manufactured for this purpose excel "home-made" compounds. Inspect all parts as they are installed. Parts of specific interest that require special inspection differ in the two instruments illustrated.

We will first consider the meter in Fig. 1. The only part that must be replaced is the float pin. It should be carefully fitted into the float arm. The hole in the float arm may enlarge slightly over a period of years; if the enlargement exceeds 0.003″, the arm may be placed on the corner of a vise with the hole at the corner. Lightly tap the edge of the arm, pinching the hole down. This will tend to elongate the hole, which affects calibration, though not usually detectably. If the hole is elongated too much, or the size exceeds 0.003″, replace the float arm. The hole size may be determined by using a drill of known size, and measuring the float pin with micrometers.

The next thing to consider is the float shaft. Place the shaft on a float surface and roll it over, observing whether it may be bent. If so, it must be straightened or replaced. If it is replaced it should be "lapped in" with grinding compound. This is accomplished by installing it in the meter. The very lightest compound or rouge is used. Loop a string around the shaft and rotate; there must be no end-play. There must be no tendency to lift the shaft while lapping because this will result in an oval hole being lapped in the seats. This also happens if the lapping is over-done. (The foregoing does not apply to "Teflon" bearings.)

After removing the lapping compound, reinstall the bearing and float. Adjust so there is no detectable end-play and no force against the seats. If the bearing used is of the old type, it should be packed with a suitable grease before inserting the shaft (prior to installing in the meter body). The float then can be tightened to the shaft, being sure to center the float in the chamber.

After the case is installed with chart drive and plate, lay a "straight edge" across the chart surface portion of the chart hub. This will enable you to ascertain the proper chart clearance—that is, if it is not protruding too far as mentioned previously. A #4 tapered reamer is used to obtain proper size of the hub. The chart should be practically flat on the plate. A slight clearance of 1/16″ will not be significant.

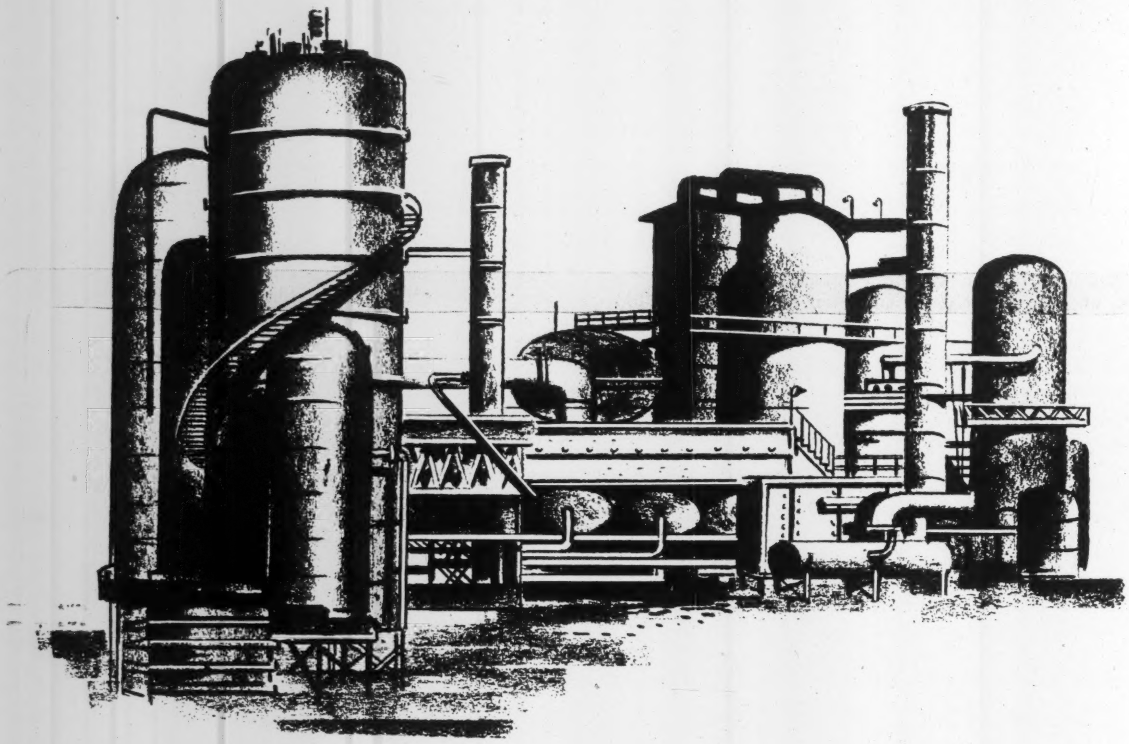
The instrument in Fig. 2 requires the same check on the float shaft. A bent shaft in either instrument is the result of careless handilng, often caused during disassembly of the meter.

The float in the meter of Fig. 2 should be checked as follows: The coil spring can be checked with a light pull; if it seems sufficiently strong it does not need replacement. See if the float hangs straight; it may be adjusted at the top of the float stem. When inserting the check floats, place each float in the same leg from which it was removed. Force the floats up their respective legs as far as they will go, then gently pull them down a bit. Check to see if they drop far enough to seat and float high enough to permit free passage of mercury.

The stuffing box is inserted (without shaft) and filled with lubricant, then the shaft is inserted. When the pen bracket is attached to the bearing shaft there should be a slight end-play. After this the float is installed. If the range tube has been removed, a "straight-edge" should be held across the bottom of the legs for leveling when replacing the tube; this is to permit proper seating of the metallic gaskets.

The only thing that merits mention regarding the chart drive is to see that there is no side play in the chart drive shaft.

These servicing tips are simply aids—they are not complete service instructions.

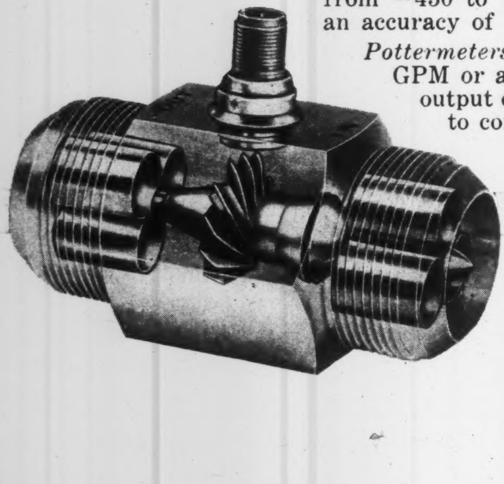


FOR VITAL FLOW CONTROL

WHETHER you're developing a new process or modernizing an old one—investigate the unique characteristics of the bearingless *Pottermeter*.

This electronic flowmeter—easily installed in any type of piping to operate at any angle, at any pressure and at temperatures from −450 to +1200°F, measures flow of any liquid with an accuracy of ±½ of 1%.

Pottermeters are available to measure flows as low as 0.07 GPM or as high as 3,000 GPM. The inherently linear output of the *Pottermeter* makes it ideal for systems to control either flow rate or total flow.



Find out how the bearingless "floating rotor" used in the *Pottermeter* can give you more precise flow measurement, longer trouble-free service life, and more accurate flow control.

Write for Bulletin PS-1

Potter

POTTER AERONAUTICAL COMPANY
Route 22 • Union, New Jersey • Phone MUrdock 6-3010
Makers of "Potter Engineered" products

For more information circle **206** on inquiry card.

There is No Distortion of the Tubes.....

even when tied in a knot

CRESCENT

POLYETHYLENE

INSTRUMENT
TUBES

MULTITUBE

with *Spirally Cabled* Tubes

For Instrument and Control Tubing

CRESCENT POLYETHYLENE MULTITUBE is composed of 2 to 19, ¼″ O.D. Polyethylene tubes up to 1000 feet in length, spirally cabled together to allow bending with a short radius without distortion of the tubes. The tubing assemblies are protected by a flexible interlocked galvanized steel armor (Type PA), or by a tough corrosion-resistant thermo-plastic sheath (Type PT). Tubes are furnished in seven contrasting colors for ready identification of each tube at both ends. Both constructions are flame retarding.

Economy is achieved in the initial cost of CRESCENT POLYETHYLENE MULTITUBE and its accessories, as well as in substantial savings in labor costs of installation. Moderate to long length runs of light weight and compact MULTITUBE assemblies result in fewer connections and fittings, lower cost for supports or racks, ease of mounting, less space being used.

CRESCENT POLYETHYLENE MULTITUBE can be pulled through conduit or raceways.

Send For Bulletin

Giving Complete Information

And Engineering Data

Shown here—
19 TUBES
TYPE PT

CRESCENT

INSULATED WIRE & CABLE CO.

OLDEN & TAYLOR STS., TRENTON, NEW JERSEY

For more information circle **64** on inquiry card.

INSTRUMENTS and AUTOMATION

New Instruments

CONTENTS OF THIS DEPARTMENT

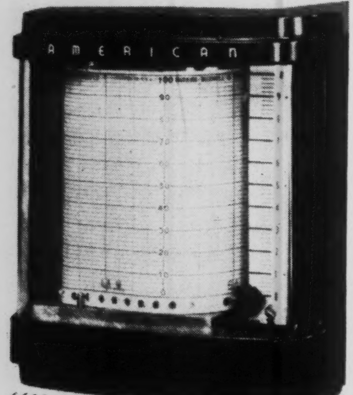
Amplifiers 560
Aviation 536
Computing 534
Counting 528
Data Processing 534
Electrical Components 564
Electr-instrument Accessories 559
Electrical Instruments 556
Electrical Testing 552
Electromechanical Components 569
Gaging 548
Laboratory Equipment 544
Mechanical Components 575
Mechanical Testing 548
Miscellaneous 582
Nucleonics 538
Power Supplies 560
Pressure 524
Process Control 520
Shop Equipment 542
Speed 530
Telemetering 532
Temperature 527
Time 530
Vacuum 524
Valves 578

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 615

PROCESS MEASUREMENT and CONTROL

PROCESS RECORDER AND ON-OFF CONTROLLER

New "American-Microsen Series 130 Electronic Recorder" features a measuring element "more than 50,000 times more powerful than conventional direction-deflection movements," hence a pen-drive mechanism with ample power to operate electric contacts without loss of accuracy. It records on a 3" wide continuous strip chart (or IBM type card chart) with rectilinear coordinates; is available in ranges from 0-200 ua to 0-100 ma and from 0-20 mv to 0-100 v with input sensitivity to 6700 ohms per volt. Accuracy within 0.5% and repeatability 0.25% of range; response speed 0.5 sec for 63% of a step change (0.2 sec on special order). Flipping a switch lengthens response time by a factor of four when user desires to damp out unwanted fluctuations. Recording mechanism can be omitted when a rugged contact-making instrument is required.—*Industrial Controls Div., Manning, Maxwell & Moore, Inc., Stratford, Conn.*

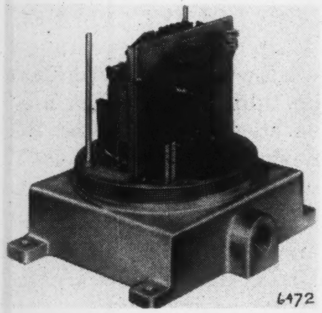


6609

For more information circle **301** on inquiry card.

CONTROL UNIT FOR REMOTE MEASURING SYSTEM

New "Remote Function Control" unit is for use with maker's "Telepulse Level and Temperature Gaging System" for limited supervisory control and operation of remote equipment. It can operate relays for controlling motorized valves, or starting and stopping of motors or pumps. Systems can be used between any points where communications facilities reach, such as private or leased wires, carrier or microwave. Addition of new function control to an existing measuring system can be accomplished easily: no increase in communication facility requirements. Available in explosion-proof or weatherproof enclosure.—*Shand & Jurs Co., Berkeley 10, Calif.*



6472

For more information circle **302** on inquiry card.

24-ELEMENT MONITOR

New "Model 20 Visual Monitor" comprises 24 mirror galvanometers for simultaneous display, on a 3" x 4" ground-glass screen, of 24 signals from thermocouples, pressure pickups, strain gages, etc. Combination of low-period galvanometers and long-path optical system permits presentation of electrical signals up to 42 cps with only 80 microamps required for full-scale deflection. Spot intensity is sufficient to permit photography or viewing under high illumination. Instrument can be shock-mounted.—*Century Electronics & Instruments, Inc., Tulsa Oklahoma.*

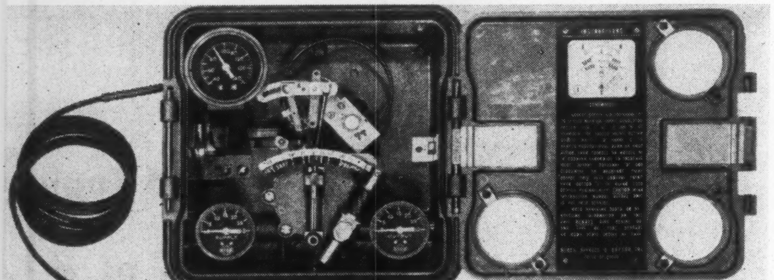
For more information cicle **303** on inquiry card.

MULTI-TANK CONTROLLER

New "Model ARPT-12 Multi-Point Controller," for multi-tank installations in electroplating plants, is a single housing containing electronic

AUTOMATIC TEMPERATURE CONTROLLER

New "Type 1460" temperature controller has a vapor-pressure type of thermal system available in various ranges between extreme limits of 0°F and 335°F. It is of pneumatic control type and its mode of control can be adjusted from 100% throttling down to on-off snap action.—*Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Missouri.*



6515

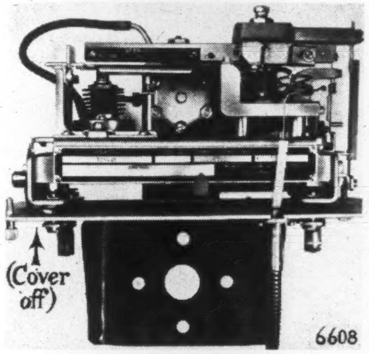
For more information circle **304** on inquiry card.

controller and automatic switching device to connect various test points or conductivity cells into controller circuit, as well as for switching solenoid valves. It automatically switches in rotation up to twelve test points. When a tank is found to be outside pre-set limits, its valves are opened and closed automatically.—*Industrial Instruments, Inc., Cedar Grove, N. J.*

For more information circle **305** on inquiry card.

PNEUMATIC TRANSMITTER

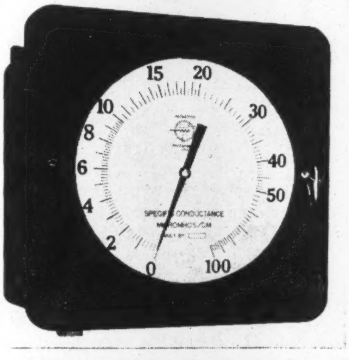
New "Tel-O-Set" transmitter converts process temperatures (from −375 to 1,000°F) or pressures (from 40 to 600 psia or psig) to a standard 3-15-psi output. Simple adjustments make it possible to vary the span width or shift it anywhere within range of instrument. New unit is shock mounted; compensates for ambient temperature and barometric pressure changes; operates on force-balance principle which minimizes wear; has universal mounting bracket.—*Industrial Div., Minneapolis-Honeywell, Philadelphia 44, Pa.*



For more information circle **306** on inquiry card.

INDICATOR-CONTROLLER WITH PNEUMATIC TRANSMITTER

Newly available with pneumatic transmitter as well as with micro switches for electrical control, "Type RI Indicator-Controller," designed primarily for measurement and control of solution concentration, is a self-balancing ac Wheatstone bridge available with either manual or auto-



THE WELCH DENSICHRON®

ELECTRONIC DENSITOMETER

- High Accuracy and Sensitivity
- Great Stability and Fidelity
- Simple Operation

PROBE

NO. 3830A DENSICHRON

PATENT NO. 2424933

The Welch Densichron is an electronic densitometer of good sensitivity and unusually high stability. It can be employed either for quantitative measurement of optical density, or as a sensing device for automatic control of various industrial processes in which constancy of transmitted or reflected light is a criterion of the quality or uniformity of the product.

It consists essentially of a probe unit containing a photoelectric tube for detecting light energy and an amplifier to which it is connected by a flexible cable. The amplifier incorporates a milliammeter calibrated to indicate either optical density on a "log" scale or percent transmission on a "linear" scale, depending upon the model.

Although the Densichron can be used in a wide variety of ways it is a simple device to use and requires no special operator skill. It will perform satisfactorily in routine operations for long periods of time with little or no servicing, yet is readily adaptable to innumerable types of special measuring techniques.

3830A. DENSICHRON WITH BLUE PROBE. This consists of the amplifier with logarithmic-scale meter, blue-sensitive probe, metal probe support, five different measuring apertures, a cone with ⅛-inch aperture, and a set of instructions. The amplifier operates on 115 volts, 60-cycle A.C., only, except on special order. **Each, $225.00**

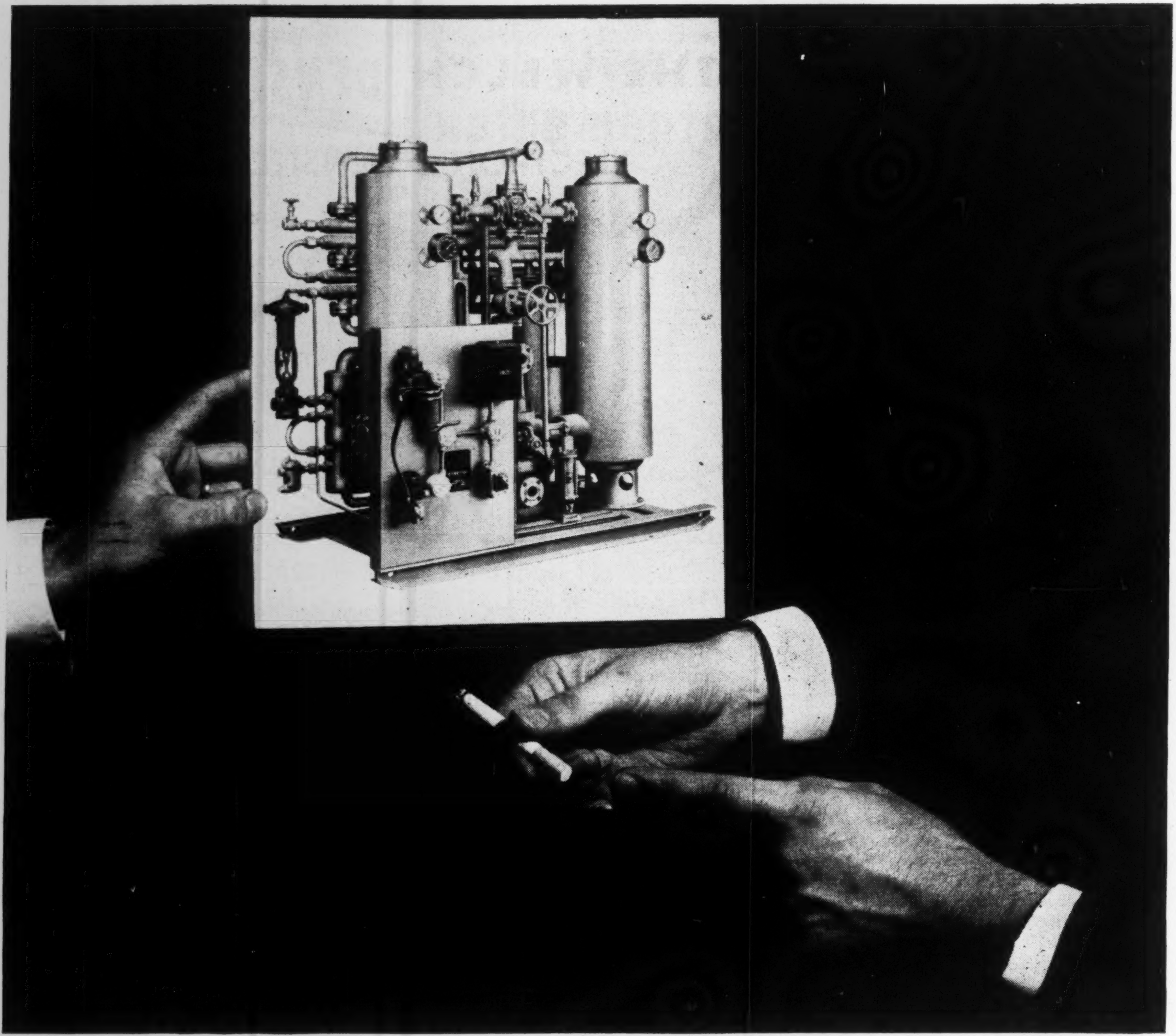
3830B. DENSICHRON WITH RED PROBE. This is identical with No. 3830A except that a red-sensitive probe is furnished in place of the blue-sensitive probe. **Each, $225.00**

3832A. REFLECTION UNIT. When coupled to the Densichron amplifier, this unit becomes a convenient reflectance meter. It has a self-contained light source, filter wheel, and phototube. Power for the lamp is taken from the amplifier through the same connector normally used for the probe. A viewing port permits the head to be correctly placed over the area to be measured. The unit includes optics for both small and large spot work, a calibrated gray scale, and three vitrolite working standards. **Each, $110.00**

WRITE FOR 12-PAGE BOOKLET GIVING OPERATION CURVES, RESULTS OF LABORATORY TESTS AND OTHER VALUABLE INFORMATION.

W. M. WELCH SCIENTIFIC COMPANY
DIVISION OF W. M. WELCH MANUFACTURING COMPANY
ESTABLISHED 1880
1515 Sedgwick Street, Dept. B Chicago 10, Illinois, U. S. A.
Manufacturers of Scientific Instruments and Laboratory Apparatus

For more information circle **66** on inquiry card.



"How can you compare a Pritchard Hydryer with a filter on a cigarette?"

"You know how a cigarette filter removes unwanted materials in your smoke? Well, the Pritchard Hydryer removes or 'grabs' the moisture in the air we use to operate our instruments."

"Is this 'grabbing' action the same in both?"

"Not exactly. You see the 'grabbing' action, as you call it, in the Hydryer is accomplished by an adsorption process in which solid adsorbents are used to reduce the moisture content of the instrument air stream. In a cigarette, the filtering is purely a mechanical action."

"Why are we so interested in dry air for our instruments?"

"First, because our precision instruments must have exceptionally dry air to operate accurately, and second, because moisture in our air lines can cause corrosion and freeze-ups in cold weather."

"How about the capacity of our Hydryer?"

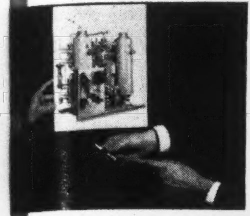
"Right now we're getting air delivered continuously with a dew point temperature not in excess of —20°F.; capacity, 420 CFM at standard conditions; pressure 100 psig; temperature, 80°F."

"No more frozen or corroded air lines for us then!"

"Not with our Pritchard Hydryer."

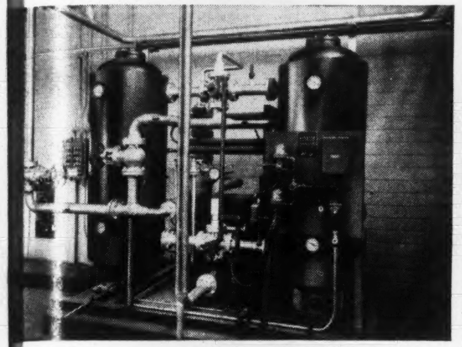
J. F. PRITCHARD & CO. OF CALIFORNIA
4625 Roanoke Parkway, Kansas City 12, Mo.

For more information circle 67 on inquiry card.



"How can you compare a Pritchard Hydryer with a filter on a cigarette?"

The Pritchard **HYDRYER**®
Unmatched for Continuous Delivery of Dry Instrument Air!

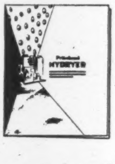


Precision automation instruments demand a constant source of extremely dry air for accurate operation. The Pritchard HYDRYER has proved its ability to deliver air that is free from damaging moisture. Only in a Pritchard HYDRYER do you get all of these features:

- NO WASTE—100% of all air or gas entering the HYDRYER is dried without loss.
- FULL LINE PRESSURE REACTIVATION—Pressuring and depressuring of adsorbers between cycles is eliminated.
- PURGING ELIMINATED—The Type A HYDRYER uses inlet main air streaming for reactivation.
- LONGER ADSORBENT LIFE.
- REACTIVATED GAS PRE-HEATED
- NO MOVING PARTS
- SIMPLIFIED OPERATION
- REDUCED EQUIPMENT AND LINE SIZES

. . . plus many more advantages.

SEND FOR BULLETIN



Write today on your company letterhead for Pritchard bulletin No. 16.0.081. This complimentary bulletin tells you the many ways HYDRYERS can help you solve your instrument air problems.

DUSTRY'S PARTNER FOR PROGRESS

J.F. Pritchard & Co.
OF CALIFORNIA
A DIVISION OF J. F. PRITCHARD & CO.
Dept 519, 4625 Roanoke Parkway
Kansas City 12, Mo.

ING TOWERS • GAS & AIR TREATING EQUIPMENT
ESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

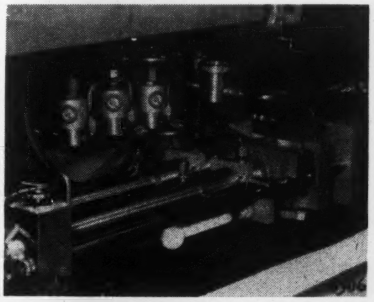
For more information circle **67** on inquiry card.

matic temperature compensation for electrolytic measurement.—*Industrial Instruments, Inc., Cedar Grove, N. J.*

For more information circle **307** on inquiry card.

INFRARED ANALYZER FOR COMPLEX MIXTURES

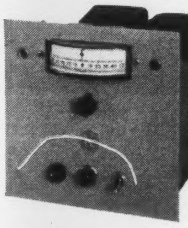
New "Cary Model 70" dual-beam non-dispersive analyzer employs selective detectors; operates by measuring loss of energy of an infrared beam in passing through sample; makes possible automatic analysis of difficult process streams.—*Applied Physics Corp., 362 W. Colorado St., Pasadena, Calif.*

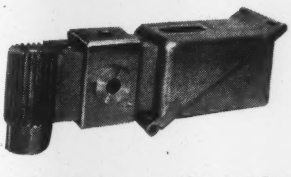


For more information circle **308** on inquiry card.

CONTINUOUS ANALYZER

New "Spectrostat" provides a new method of control in manufacturing processes through use of wavelength absorption from a continuous flow of materials or finished products (gases, liquids, slurries, sheets or a flow of unit solids); provides continuous sampling of any of these forms and indicates direction of deviation beyond set limits by visual and/or audible warning. A 50-millivolt proportional output provides direct process control. Unique feature makes possible simultaneous monitoring of color and turbidity; or two or more components of a stream, by use of single instrument.—*Atomic Instrument Co., Cambridge, Mass.*

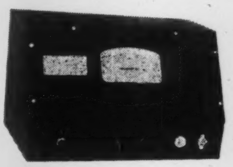




For more information circle **309** on inquiry card.

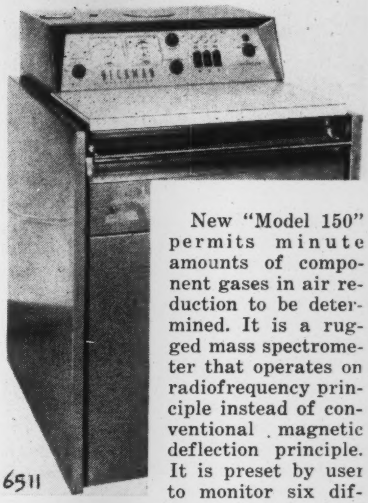
SPECTROSCOPIC ANALYZER

New "Model AA-1 Analyzer" makes possible automatic processing of pharmaceuticals, plastics, rubber, chemicals, food, paper, etc.; is designed to be used in conjunction with narrow-band infrared, ultraviolet, and visible filters; has universal application to emission, transmission, or absorption methods.—*Axler Associates, Inc., 102-42 43d Ave., Corona, N. Y.*



For more information circle **310** on inquiry card.

RF GAS ANALYZER



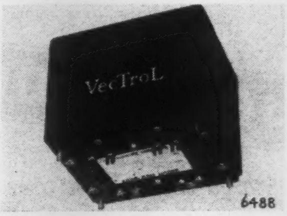
6511

New "Model 150" permits minute amounts of component gases in air reduction to be determined. It is a rugged mass spectrometer that operates on radiofrequency principle instead of conventional magnetic deflection principle. It is preset by user to monitor six different masses. (If he wishes to monitor other masses he changes setting.) Tuning to any of these six is accomplished by flipping a switch; and an available accessory automatically monitors all six in rotation in 1 min (each in 10 sec).—*Beckman Div., Beckman Instruments, Inc., Fullerton, Calif.*

For more information circle **311** on inquiry card.

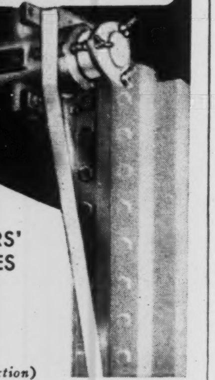
ELECTRONIC CONTROLLER

New "Packaged Vec-TroL" unit gives proportional control of 60-cps single-phase half- or full-wave thyratron outputs up to several kilowatts, with dc control signal less than 1 milliwatt. Four isolated dc control



6488

You Get Even, No Glare
LOW COST LIGHTING
for Gages, Rotameters, etc.
with JERGUSON
Explosion-Proof
GAGE ILLUMINATORS



UNDERWRITERS'
LABORATORIES
APPROVED

Single Section Jerguson Illuminator illustrated (also made in double section)

YOU get even, no glare, Low Cost Lighting with Jerguson Illuminators . . . the improved illuminators that are unexcelled for gages, rotameters, etc. They give you ideal illumination with safety . . . and make possible faster, easier, accurate reading.

Jerguson Illuminators use the principle of solid wedge lighting to give you *clear, even lighting, without bright spots.* Light flows through the plastic wedge and is reflected evenly. A single bulb gives you better illumination at a cost so low that savings quickly pay for the illuminator.

Jerguson Illuminators are approved by Underwriters' Laboratories and are built in accordance with their Standard for Electric Lighting Fixtures for use in hazardous locations for Class 1, Group D Services. Made in a variety of sizes; also available in a non-explosion proof model.

Investigate Today. Write for Data Unit on Jerguson Illuminators

JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Fellsway, Somerville 45, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

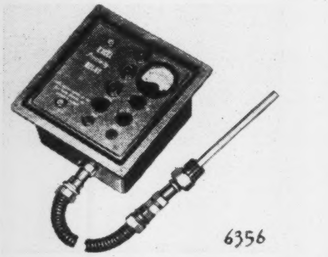
For more information circle **68** on inquiry card.

windings will provide control in accordance with several independent signals. "VecTroL" is fail-safe. Applications include process control, adjustable-speed motor drives, program speed controls, welding or electrochemical current control, also high-sensitivity designs for thermocouple signals down to 0.001 microwatt.—*Vectrol Engineering, Inc., P.O. Box 1089, Stamford, Conn.*

For more information circle **312** on inquiry card.

PROXIMITY RELAY

New control relay is actuated by proximity of movable material—liquids, granular or solid objects—to its stationary probe; in turn actuates solenoid valves, power relays, motor starters, signaling devices, etc. Level control from a fraction of an inch to several feet; also interface control and control of multi-material operations. Negligible-potential probe allows use in hazardous areas.—*Excel Electric Service Co., Inc.,* 2121 *S. Western Ave., Chicago* 8, *Ill.*



6356

For more information circle **313** on inquiry card.

ELECTROPLATING CONTROL

New "Model A" provides individual automatic plating-cycle control for each tank. It comprises a control box having two signal lights, and time switch. Operator starts current flow and plating cycle by setting time on switch dial. During plating cycle, green light is on; red light signals end of plating cycle and shows that current has been cut off. Installation is made easily by removing cathode bar from tank and replacing it with control box. Standard models have 600-amp capacity, 5 to 15 v.—*Hoffman Control Co.,* 6804 *Park Ave., Cleveland, Ohio.*

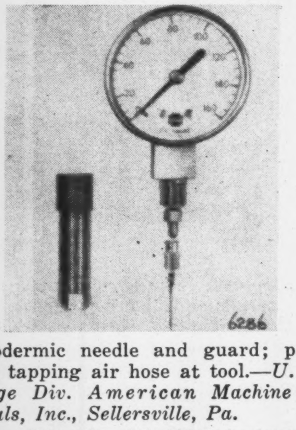
HOFFMAN
AUTOMATIC CONTROL
PLATING SWITCH

For more information circle **314** on inquiry card.

PRESSURE and VACUUM

"HYPODERMIC-NEEDLE" GAGE

New 2" pressure gage for determining available air pressure at point of use comes equipped with a BD-20 hypodermic needle and guard; permits tapping air hose at tool.—*U. S. Gauge Div. American Machine & Metals, Inc., Sellersville, Pa.*

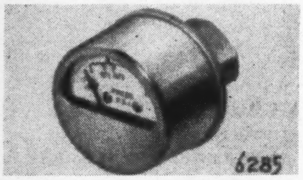


6286

For more information circle **315** on inquiry card.

SHOCK-RESISTANT GAGE

New 1" pressure gage for aircraft and guided missiles withstands extreme shock and vibration; has accuracy of 2.5%; passed test more severe than MIL-E-5272A.—*U. S. Gauge Div. American Machine & Metals, Sellersville, Pa.*

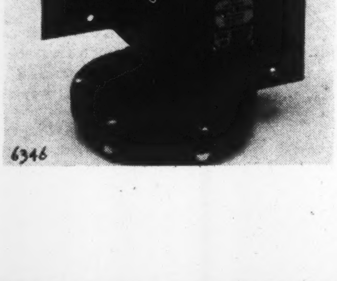


6285

For more information circle **316** on inquiry card.

VACUUM SWITCH

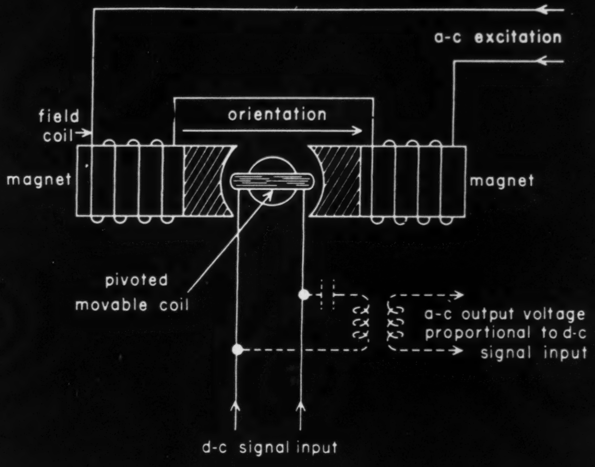
New "Cat. 110V Vacuum Static Pressure Control" features sensitivity and ease of adjusting operation point. Each unit is specifically designed for



6346

New Principle OF D-C, A-C CONVERSION

(Actual size)


a-c excitation
field coil
orientation
magnet
magnet
pivoted movable coil
a-c output voltage proportional to d-c signal input
d-c signal input

INSTRUMENTS *by* WESTON

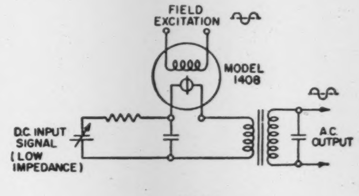
NEW WESTON

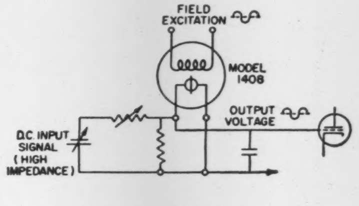
INDUCTION MODULATOR

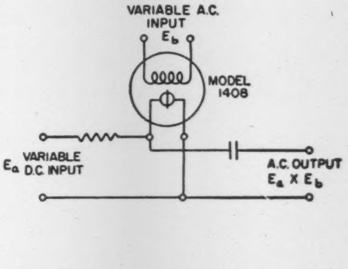
- has no contacts
- provides conversion gain
- output wave form sinusoidal

In contrast to conventional transducers, the compact light-weight Induction Modulator is of hermetically sealed-in construction, making it impervious to moisture, dust and other exposures . . . is never subject to contact troubles . . . presents a constant resistance to the d-c signal input, and is unaffected by pick-up from stray fields. Further it is extremely rugged, sufficient to assure trouble-free service in airborne devices and other electronic equipment.
For complete information write,
Weston Electrical Instrument Corp.,
614 Frelinghuysen Ave., Newark 5, N. J.
A subsidiary of Daystrom, Inc.

TYPICAL CIRCUITS


FIELD EXCITATION
MODEL 1408
D.C. INPUT SIGNAL (LOW IMPEDANCE)
A.C. OUTPUT


FIELD EXCITATION
MODEL 1408
OUTPUT VOLTAGE
D.C. INPUT SIGNAL (HIGH IMPEDANCE)


VARIABLE A.C. INPUT
E_b
MODEL 1408
E_a VARIABLE D.C. INPUT
A.C. OUTPUT
$E_a \times E_b$

For more information circle **69** on inquiry card.

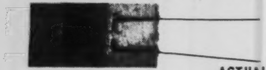
SEND FOR T-54

TEMPERATURE MEASUREMENT and CONTROL BROCHURE

RdF STIKON®

RESISTANCE THERMOMETER ELEMENTS

Eliminate Effect of Ambient Air Temperatures


ACTUAL SIZE

Highly-stable RdF Stikons respond to changing temperatures quickly and accurately (to one-half a degree centigrade). Because of the element's thin construction (.005 to .010 inches), and the extremely close proximity of its temperature-sensitive grid to the measured surface, the effect of ambient air temperature is practically nil. When used in a bridge, *an RdF Stikon may easily produce output voltages several hundred times higher than the output of the most sensitive thermocouples.*

SUMMARY OF CHARACTERISTICS

Type	Resistance at 70°F (ohms)	Temperature Range F*
BN-1	81.7	—100° to +300°
BN-3	50.	—100° to +300°
BN-4	200.	—100° to +300°
PN-1	50.	—100° to +180°
PN-2	200.	—100° to +180°
SN-1	100.	—100° to +500°

* For continuous operation — may be used intermittently at higher temperatures. See RdF Stikon Brochure T-54.

Type	Wafer Material	Size (inches)
BN-1	Bakelite	½ x 1½ x .005
BN-3	Bakelite	5/16 x ¾ x .006
BN-4	Bakelite	9/16 x ⅞ x .006
PN-1	Paper	5/16 x ¾ x .006
PN-2	Paper	9/16 x ⅞ x .006
SN-1	Silicon-Glass	9/16 x 17/16 x .010

Types BN-1, BN-3 and PN-1 are marked to 0.2 ohms, while types BN-4, PN-2 and SN-1 are marked to 0.5 ohms.

Arthur C. Ruge
Associates, Inc.

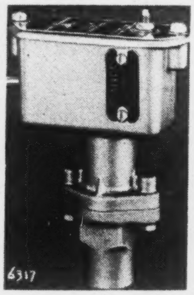
ACRA
ARTHUR C. RUGE ASSOCIATES INC
733 CONCORD AVE
CAMBRIDGE 38, MASS

For more information circle **72** on inquiry card.

use on low vacuums where regulation is required in inches of water column. Standard units available 0-1" wc vacuum and 0-4" wc vacuum; minimum on-off differentials of 0.1" wc are available.—*The Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.*

For more information circle **317** on inquiry card.

PRESSURE SWITCH


6317

New "C9621" has a calibrated plate scale for setting before or after installation. Tamperproof inner indicator is visible through a window in plate. Once desired pressure is set, external adjustment can be locked in place. Adjustment range, 15 to 3,000 psi, can be covered by one of 4 classes of switch. Fixed actuation value, 10 to 250 psi, depending on switch setting. Piston type element can perform millions of cycles; is not sensitive to jarring.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

For more information circle **318** on inquiry card.

PRESSURE PICKUP

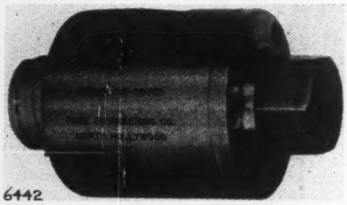
New "Model AP-17" miniature flush-diaphragm pressure pickup is of variable-reluctance type. Ranges extend from 0-15 psia to 0-5000 psig and dynamic characteristics permit flat response from static to extremely high frequencies. Diaphragm is integral with stainless-steel body; its deflection alters air gap between it and an E-core pickoff assembly. This absence of mechanical coupling, plus rigidity of internal assembly, results in high natural frequency (5000 cps) and maximum acceleration sensitivity of 1% per 100 G, corresponding to 0-15-psi range.—*North American Instruments, Inc., 2420 North Lake Ave., Altadena, Calif.*

6433

For more information circle **319** on inquiry card.

PRESSURE PICKUP

New "Model P-1," of magnetic reluctance type, is available in full-scale ranges from 0.25 to 100 psig or psid. (In differential pressure service, nominal maximum line pressure rating is 500 psig.) New pickup can be operated in recording and control systems compatible with inductance ratio input devices. Diaphragm is magnetically coupled to a pickoff system embedded in body, whence extreme mechanical rigidity and ability to measure high-frequency components of pressure transients. High electrical output can be realized over a broad range of excitation frequencies. Accuracy rating 1%.—*Pace Engineering Co., 6914 Beck Ave., North Hollywood, Calif.*

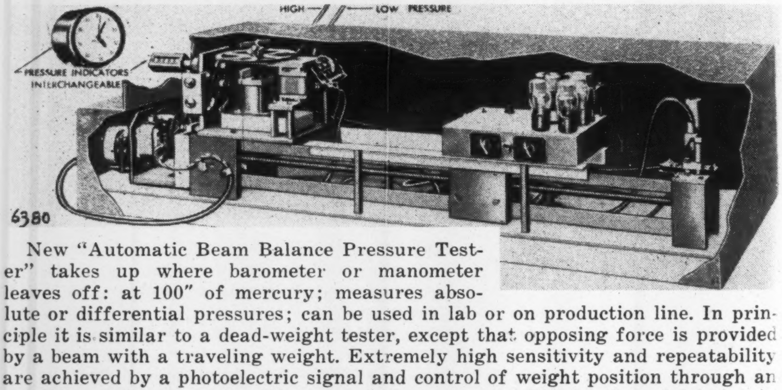

6442

For more information circle **320** on inquiry card.

PRESSURE PICKUP

New multi-purpose pressure pickup features unique unitized construction providing easy assembly, calibration and repair. Built into unit are two pressure-gage elements, an absolute

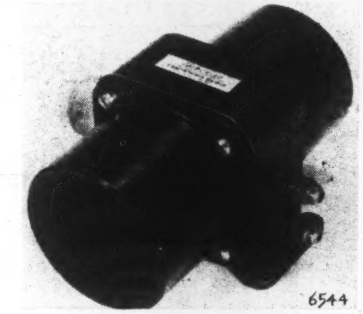
SELF-BALANCING PRESSURE-GAGE CALIBRATOR



6380

New "Automatic Beam Balance Pressure Tester" takes up where barometer or manometer leaves off: at 100" of mercury; measures absolute or differential pressures; can be used in lab or on production line. In principle it is similar to a dead-weight tester, except that opposing force is provided by a beam with a traveling weight. Extremely high sensitivity and repeatability are achieved by a photoelectric signal and control of weight position through an amplifier and servomotor-driven precision leadscrew. Elimination of friction in both pressure cylinder and beam pivots further enhances over-all accuracy and sensitivity.—*Ideal-Aerosmith, Inc., 12909 South Cerise Ave., Hawthorne, Calif.*

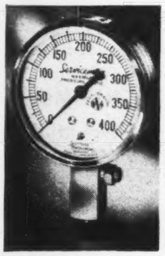
For more information circle **321** on inquiry card.



nd a differential type, each with dynamically-balanced and easily-adjusted linkage between diaphragms and two precision voltage-dividing resistors. Range includes minus 1000 ft to 0,000 ft altitude utilizing both resistor elements, and from 205 to 590 knots air speed.—*Fairchild Controls orp., Components Div., 225 Park ve., Hicksville, N. Y.*

r more information circle **322** on inquiry card.

MAXIMUM PRESSURE GAGE



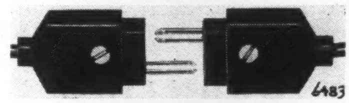
New "Serviceman Maximum Pressure Gauge" relieves serviceman of constant gage watching and gives visual proof of maximum pressure reached over any given period of time. Pointer is returned to zero by pressing push button on side of socket. Standard range 0-400 psi.—*Jas. P. Marsh Corp., 3501 W. Howard St., Skokie, Ill.*

or more information circle **323** on inquiry card.

TEMPERATURE

MINIATURE TC CONNECTOR

New miniature thermocouple connector is said to be the smallest and lightest-weight ever manufactured; is particularly advantageous where space is limited, also where short installation time is desirable. Wire breakage is virtually eliminated and connector can be re-used many times. Available with shoulder cap for panel mounting; can be supplied with positive lock against vibration.—*Thermo-ouple Products Co., 1515 N. 25th ve., Melrose Park, Illinois.*



or more information circle **324** on inquiry card.

THERMOREGULATORS

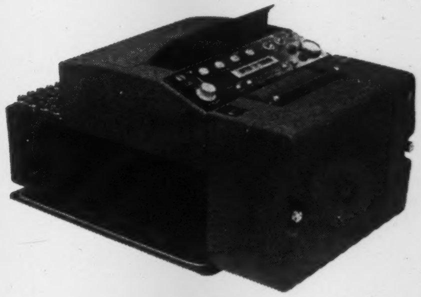
Newly redesigned "Sealed Contact Thermo-Regulators" provide higher sensitivity, longer life and greater flexibility of operation than old mod-

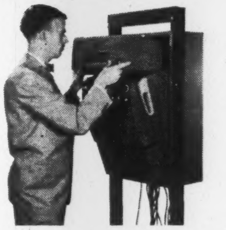
vital tests?

lots of data?

Here's the acknowledged peak of recording oscillograph development – CEC's Type 5-119, usable for over 90% of all static-dynamic tests, regardless of their complexity. An unusual group of *built-in* safeguards against data loss has proved especially valuable in aircraft flight testing and in missile testing, where conditions are often impossible to duplicate and lost data can mean tens of thousands of dollars. In the air or on the ground, you can be *sure* when you use the CEC 5-119.

then try CEC's 5-119 recording oscillograph





Also, the 5-119R, especially engineered for vertical installation. Effectively shock mounted, using little space, it's ideal for both stationary and mobile rack mounting... tilts forward easily for loading and adjustment.

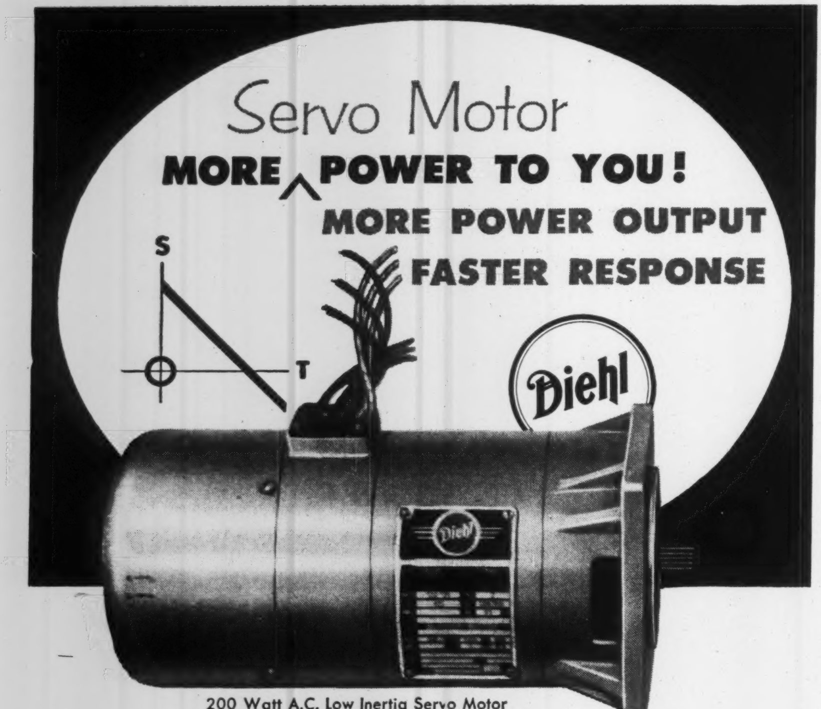
The 5-119 records up to 50 channels on records 12″x250 ft at speeds from 0.1 to 100 inches per second. *Instant* speed change of 10:1 is effected through a simple switch control. It uses standard CEC Galvanometers, with linear frequency response from 0 to 3000 cps. All controls and warning lamps are located on the front panel.

For complete information about the 5-119 oscillograph, write today for CEC 1536B-X2.

Consolidated Electrodynamics
CORPORATION
formerly Consolidated Engineering Corporation
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
300 North Sierra Madre Villa, Pasadena, California

Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

For more information circle **71** on inquiry card.



200 Watt A.C. Low Inertia Servo Motor

Short life, overheating and unsatisfactory response—these are your only rewards when you use an underrated Servo Motor on a job demanding a bigger rating. If *faster* response and *more* output are what you need to solve existing problems in your Servo Motor applications—it's time to investigate DIEHL Servo Motors.

The DIEHL ¼ HP (200 watt output) Servo Motor has proved especially successful in overcoming problems in a wide range of applications. Capable of continuously delivering rated maximum output without exceeding rated temperature rise when excited at rated voltage and frequency from a suitable polyphase power source, these open-type 60 and 400 cycle low inertia Servo Motors feature an integrally-mounted auxiliary motor-blower. A look at the other specifications—and at your Servo Motor requirements—may reveal many practical uses for these *higher powered* DIEHL Servo Motors in your operations. ***Write today for complete information on Servo Motors rated up to 1 HP (750 watt output).*** IA356

SPECIFICATIONS

DIEHL Number	ZP105-2212-1	ZP105-2217-1
Output (watts)	200	200
Frequency (cycles)	60	400
Poles	2	6
Reference Phase (volts)	115	115
Control Phase (volts)	115	115
Reference Phase (watts)	380	410
Control Phase (watts)	380	410
Control Phase Impedance (Ohms)	30	19
Locked Torque (Oz. In.)	190	105
Moment of Inertia (Oz. In.^{2})	6.60	6.60
Theoretical Acceleration (Rad/sec.^{2})	11100	6140
Weight	14 lbs. 8 oz.	14 lbs. 8 oz.

Booth 3
RADIO
ENGINEERING
SHOW
Kingsbridge
Palace, N. Y.
MARCH 19-22,
1956

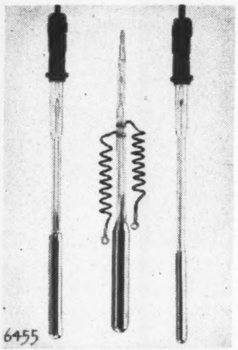
other available components

A.C. SERVOMOTORS • A.C. SERVOMOTORS WITH A.C. TACHOMETERS • A.C. SERVOMOTORS WITH D.C. TACHOMETERS • A.C. AND D.C. TACHOMETERS • D.C. SERVO SETS • RESOLVERS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO.
Finderne Plant SOMERVILLE, N.J.

For more information circle **70** on inquiry card.

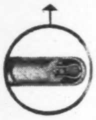


els; are available in adjustable typ with mercury-to-mercury contacts; adjustable type with mercury-to-platinum contacts; and preset type wit mercury-to-mercury contacts. Adjustable models have a range from —35 to 700°F; preset model (—35° t 212°F) is factory-set. All models ar sensitive to 0.05C°.—*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **325** on inquiry card.

THERMOCOUPLE ASSEMBLY

New "Safetywell fast-respons thermocouple assembly with positiv pressure seal provides full protection

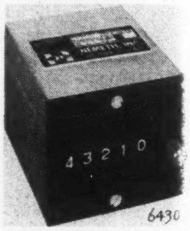


in case of well rupture; permits small-diameter TCs to be used with "greater safety than previously achieved by other methods and heavier assemblies." Fast response, whenc higher accuracy, is insured by bottoming a butt-welded TC in formed ti of a small-diameter well. Operatin ranges: pressure from vacuum t 3000 psi, temperature from —300°F to 1850°F standard (to 20,000 ps with heavier wells). TCs are C-C I-C or C-A.—*Conax Corp.*, 7811 *Sheridan Drive, Buffalo* 21, *N. Y.*

For more information circle **326** on inquiry card.

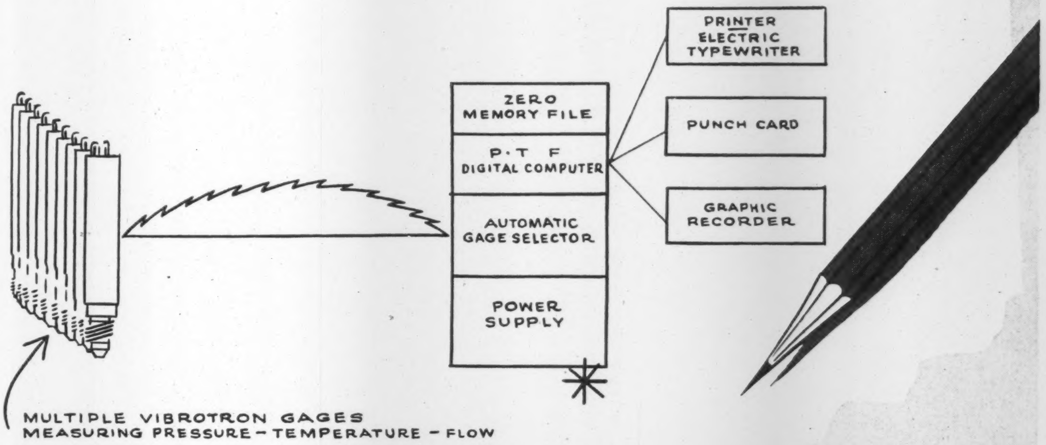
COUNTING

TWO-WAY COUNTER



New "Bi-directional Summation Counter" pulse-actuated electromagnetic counter adds and subtracts; utilizes a unique dynamically-balanced bi-directional stepping mechanism that cannot double-index during shock, vibration o excessive electrical input. Long lif (exceeding 100 million counts). Meet

Make your system COUNT!


PRINTER
ELECTRIC TYPEWRITER
ZERO MEMORY FILE
P·T F DIGITAL COMPUTER
PUNCH CARD
AUTOMATIC GAGE SELECTOR
GRAPHIC RECORDER
POWER SUPPLY
MULTIPLE VIBROTRON GAGES
MEASURING PRESSURE – TEMPERATURE – FLOW

BJ DIGITAL SYSTEMS

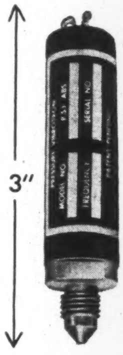
INDICATE, RECORD AND CONTROL pressure, temperature and flow with BJ Digital Systems. It's as simple as 1-2-3. ONE, BJ Vibrotron Digital Gages at remote points use frequency changes to measure pressure, temperature or flow (P-T-F) and signal this information by direct wire or radio link. Two, these frequency signals are received and directly indicated in numbers on the BJ P-T-F Digital Computer without further translation. THREE, this information in numbers can then be fed to any desired recording device or used to initiate control action and close the loop.

Only digital systems give you the direct simplicity of information in *percentage* by numbers from 000 to 999. Thus, all information has a common denominator. Variations in performance are *counted* and not compared.

The heart of BJ digital systems is the BJ Vibrotron Gage which uses a vibrating wire under tension. Pressure, temperature and flow control the tension and frequency signal.

Other Byron Jackson digital system components include. a Zero Memory File which permits simple electronic calibration of all sensing gages in the system; and an Automatic Gage Selector which sequentially selects signals from any number of gages for measurement by the P-T-F Digital Computer.

Investigate BJ digital equipment before you make a decision on your systems problem. BJ electronic engineers are ready to help you make your system *count.*



Model 101 Vibrotron

Send for special technical data file on "Make Your System Count."

BJ

Byron Jackson
DIVISION OF BORG-WARNER CORPORATION
492 East Union Street • Pasadena 1, California

For more information circle 73 on inquiry card.

TABTRON

FOR ALL DC POWER REQUIREMENTS
HIGH CURRENT PWR SUPPLIES

Variable 0-28VDC. Completely Built. Ready to Go. Full Wave Selenium Rectifier, Transformer, Variac, 4" Volt & Amp Meters, Switch, Terminals & Fuse. In Heavy Duty Steel Cabinet. Std 115 Volt 60 Cy. In OR 220V† (3 phase) to order.

Stock No.	Cont. Rating	W/Meters
T28V5A*	0-28VDC at 5 Amp	$ 50.00
T28V5ACC	5 Amp 1% Ripple	85.00
T28V5A2CC	5 Amp 0.01% Ripple	145.00
T28V12A	0-28VDC at 12 Amp	125.00
T28V12ACC	12 Amp 1% Ripple	160.00
T28V24A†	0-28VDC at 24 Amp	220.00
T28V24ACC†	24 Amp 1% Ripple	155.00
T28V50A†	0-28VDC at 50 Amp ...	225.00

*2" Meters; all others 4" Meters

VARIABLE DC LINE SUPPLY

Variable 75-135VDC. Completely Built. Ready to Go. Includes F. W. Selenium Bridge Rectifier, Filter, 4" Rectangular Volt & Ammeter, Overload cut out & components as in other supplies. Designed for cont. service. SPECIFY for 115 OR 230 VAC/60 Cycle/1 phase.

T120V5AC	75-135VDC at 5 Amp	$190.00
T120V5ACC	5 Amp 1% Ripple	240.00
T120V10AC	75-135VDC at 10 Amp ..	245.00
T120V10ACC	10 Amp 1% Ripple	295.00

NEW! BASIC SUPPLY

DC Power Supplies consisting of Transformer & Full Wave Bridge Selenium Rectifier. Mtd Wired. Std. 115V In OR 230 VAC† to order, SPECIFY. Hvy Steel Cabinet. **Less Meters.**

B12V10A	12VDC at 10 Amp	$39.00
B12V24A	12VDC at 24 Amp	81.00
B28V5A	28VDC at 5 Amp	39.00
B28V12A	28VDC at 12 Amp	83.00
B115P5A	115VDC at 5 Amp	98.00

C "TAB" FOR FAST DELIVERY SPECIALS

NEW "TABTRON" SELENIUM RECTIFIERS
ENGINEERED for INDUSTRY

"Technical Apparatus Builders" mfgrs. power rectifiers to your specs. From one amp up to and above 1000 amps, convection or fan cooled, single or 3 phase. "NEMA" & JAN. Specs.

***FULL WAVE BRIDGE • DATED & ONE YEAR GTD**

Max Amp	18VAC* 14VDC	36VAC* 28VDC	54VAC* 42VDC	72VAC* 56VDC	130VAC* 100VDC	266VAC* 217VDC	Ctr Tap AC/DC 30/12	3 Phase Bridge 120VAC 150VDC	240VAC 300VDC
1	$1.40	$2.30	$3.70	$4.45	$7.40	$25.00	$2.40	$17.10	$33.25
2	2.00	2.95	5.30	5.85	10.25	29.00	2.70	18.25	35.50
3	2.90	4.10	5.75	7.80	12.70	37.00	3.05	20.00	38.50
4	3.50	6.40	11.25	14.30	25.00	45.00	3.40	21.70	42.45
6	3.95	7.70	12.75	17.25	29.65	59.00	3.70	24.00	45.90
10	5.85	11.35	19.40	24.75	41.25	85.00	5.45	42.40	82.70
12	7.20	14.25	22.00	29.50	43.85	100.00	6.80	48.15	94.20
20	13.00	25.00	37.00	48.00	78.00	161.00	9.15	58.50	112.60
24	15.00	28.50	44.25	57.50	80.65	191.00	11.45	103.35	183.90
30	17.85	34.25	56.25	70.50	108.00	236.00	Q	135.55	259.80
36	22.35	42.00	64.75	86.50	133.65	296.00	17.20	155.10	310.40
50	29.40	54.00	105.00	115.00	173.00	405.00	27.50	206.85	413.90
100	59.00	118.00	218.00	242.00	325.00	796.00	Q	374.00	776.40
200	132.00	242.00	425.00	472.00	773.00	Q	Q	734.00	1540.

Write for Our Brand NEW Power Supply & Rectifier CATALOG PR156

NEW "TABTRAN" RECTIFIER CHOKES

CR6001	1 AMP/0.1 HY/1.4 OHM...	$ 4.50
CR6002	2 AMP/0.1 HY/.67 OHM....	5.75
CR6003	5 AMP/.07 HY/.6 OHM.....	7.90
CR6004	12 AMP/.01 HY/.1 OHM.....	14.50
CR6005	24 AMP/.004 HY/.025 OHM...	29.50

NEW "TABTRAN" RECTIFIER XFMRS

Sec (Dual†) 0-9-15-18:18-15-9-0 volts
Series Sec 0-3-6-9-12-15-18-21-24-27-30-33-36 volts

TR5007	1 Amp	†	@$ 4.50
TR5008	2 Amp	†	@ 6.50
TR5001	5 Amp	†	@ 8.65
TR5002	12 Amp	†	@ 16.50
TR5003	24 Amp	†*	@$ 35.50
TR5004	50 Amp	†*	@ 58.50
TR5005	100 Amp	†*	@ 107.00

† Wndgs in Series at ratings shown; Parallel 2x Current, Voltage 0-9-15-18.
* Dual Primary 115/220V 60 Cycle
ALL PRICES SHOWN SUBJECT TO CHANGE

TECHNICAL APPARATUS BUILDERS
109 LIBERTY ST., NEW YORK 6, N.Y.
CABLE "TABPARTS" PHONE RECTOR 2-6245

For more information circle **74** on inquiry card.

MIL-E-5272A. Operates to 60 counts per second in either direction or to 50 cps random input on dc. Available for ac with external rectifier.—*Otto R. Nemeth Labs, Inc., 2223 S. Carmelina Ave., Los Angeles 64, Calif.*

For more information circle **327** on inquiry card.

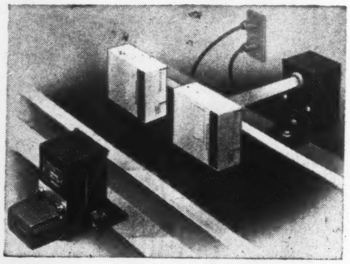
COUNTER DIAL

New "Amer-Dial" for multiturn devices where direct reading to hundredths of a turn is desired features: (1) driving ratio of 1½ to 1; (2) continuous rotation in either direction without obstruction. 2¼" diam and 1¾" depth (including counter face).—*Amerac, Inc., 116 Topsfield Road, Wenham, Mass.*

For more information circle **328** on inquiry card.

PHOTOELECTRIC COUNTER

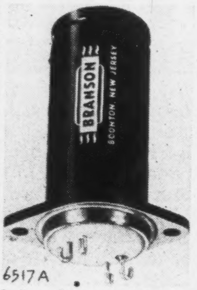
New "Counting Eye" comes wired and adjusted ready to use; provides reliable counting at distances up to 8 ft between source and relay; each object to be counted should interrupt light beam 1/16 sec or more and space following each object should permit restoration of light beam for 1/16 second or more.—*Autotron Co., Box 722-Q, Danville, Ill.*



For more information circle **329** on inquiry card.

TIME, SPEED

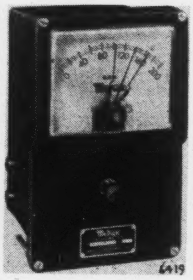
HI-TEMP TIME DELAY RELAY



New "Type TRH" thermal-type time delay relay, capable of dependable and repeatable performance in ambient temperatures of 125°C, is temperature-compensated; operates on voltages up to 125; delays available between 1 sec and 1 min; meets requirements of high-speed military aircraft.—*Branson Corp., Boonton, N. J.*

For more information circle **330** on inquiry card.

CONTACTING TACHOMETER



New "Series 42X" actuates self-contained power relays for overspeed and underspeed signals, stopping or starting equipment, opening or closing valves, etc. High and low limit pointers are independently adjustable; act as a sp-dt switch with indicating pointer acting as switch center arm. Manual reset push button resets tachometer after relays have signalled a high or low speed. Available with any of 48 different scales marked in rpm, fpm, sheets/hour, etc.—*Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.*

For more information circle **331** on inquiry card.

SPEED INDICATOR

New "Totco Chronometric Tachometer" features guaranteed accuracy of 0.01%. It is a combined chronometer and revolution counter (as well as a surface speed indicator) with a six-second period of spindle-to-counter engagement. Two models are available. "Model 944" measures to 1,000 rpm; "Model 145" to 10,000 rpm. Both come with 90° male and 60° female tip and 6"-circumference wheel tip.—*Technical Oil Tool Co., 1057 No. La Brea Ave., Los Angeles 38, Calif.*

For more information circle **332** on inquiry card.

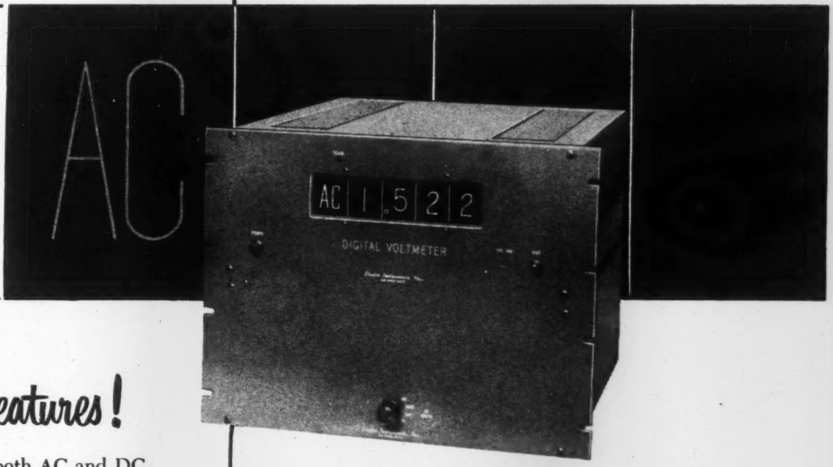
CHRONOMETRICALLY GOVERNED D-C TIMING MOTORS

New chronometrically governed dc timing motors provide the accuracy of an escapement clock and the power

At Last!

An AC Digital Voltmeter!

Now a 0.1% AC instrument plus DC in a single package . . . with digital accuracy at a glance!



Look at these features!

Extremely versatile — Having both AC and DC in a single instrument widens your applications of digital voltmeters Front panel switch is provided for quick selection of AC or DC.

AC accuracy 0.1% of reading, or 2 mv — Readings give true value of input wave shape with virtually zero phase shift error. Answers are then in terms of AC as used. DC accuracy ± 1 digit.

Frequency response to 5 kc with 11 megohms input impedance — Model 4500 is flat from 30 to 5,000 cycles at 11 megohms. Model 3500 is flat from 30 to 2500 cycles, also with 11 megohms Other models to 1 megacycle with reduced accuracy and input impedance.

Range from 1 mv to 1,000 volts — EI's unique in-line read-out display indicates 4 digits from 0.001 to 999.9 volts with range indicated by decimal position. Manual range switching on AC, automatic on DC.

Reading time averages 2 seconds — On AC balance times average two seconds; on DC one second

Quick, easy internal calibration — Front panel switch and one-point adjustment provided for instantaneous calibration. Absolute DC calibration.

Reliability — Quality components used throughout. Especially selected aged resistors assure stable, reliable life. Design techniques proved through hundreds of applications. Write for complete data.

Optional features — Available for operation with printers. Read-out may be remoted if desired. Complete specifications will be sent on request.

TWO STANDARD MODELS

	Model 4500	**Model 3500**
Display	4 digits	3 digits
Accuracy	0.1% of reading or 2 mv	0.25% of full scale
Range	0.001 to 999.9 volts	0.01 to 999. volts
Frequency response	30 to 5,000 cycles	30 to 2,500 cycles
Input impedance	11 megohms	11 megohms
Range switching		
AC	manual	manual
DC	automatic	automatic
Size	14" x 19"	7" x 19"
DC blocking	400 volts	400 volts
Calibration	internal	internal

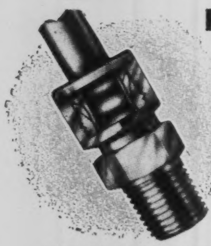
ELECTRO INSTRUMENTS INC.

3794 Rosecrans Street, San Diego 10, California

For more information circle **75** on inquiry card.

REPLACEMENT
HUMAN EYES
FOR MEN WHO DON'T LIKE TO WEAR GOGGLES

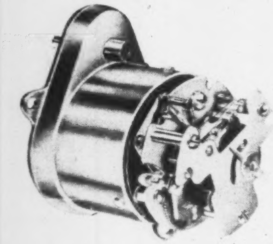
We think it is smarter to play safe. Use goggles and Swagelok® FITTINGS



GET ALL THE FACTS: Write for the Swagelok catalog. Address Dept. A-6.

CRAWFORD FITTING CO.
884 EAST 140th STREET
CLEVELAND 10, OHIO

For more information circle 76 on inquiry card.



of an electric motor; keep rate independently of load, line and temperature variations. Rate is held constant within 0.1% for line voltage variations of 20% and load variations from zero to full load.—*The A. W. Haydon Co., Waterbury, Conn.*

For more information circle **333** on inquiry card.

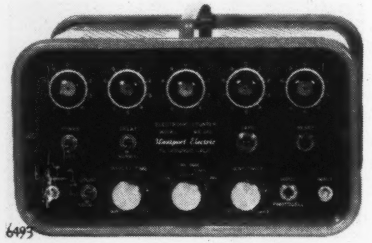
INTERVALOMETER

New "Model N-20" supplies operating pulses for flight-test and ordnance instrumentation, for process control, etc.; can be readily incorporated into systems or equipment. It supplies 1, 2, 4, 5, 8, or 10 pulses per second, selected at will and adjustable in duration; also five additional continuous intervals of ½, 1, 2, 5, and 10 seconds, which are independent of selectable pulses and also of one another and are brought out in separate circuits to output connectors. Contacts carry 10 amp noninductive at sea level. Other pulse intervals and pulse durations can be supplied.—*Photographic Products, Inc., 1000 North Olive St., Anaheim, Calif.*

For more information circle **334** on inquiry card.

TIMER-RATEMETER

New "Model WE-120" events-per-unit-time meter features cold-cathode glow transfer tubes for digital presentation; five decades; digital division of time base frequency (optional); range 10 to 100,000 cps; sensitivity 50 mv (10 mv optional); display time 0.5 to 5 seconds; stability 0.001%.—*Westport Electric, 149 Lomita St., El Segundo, Calif.*

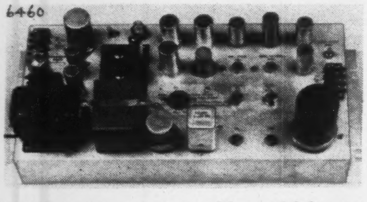


For more information circle **335** on inquiry card.

TELEMETERING

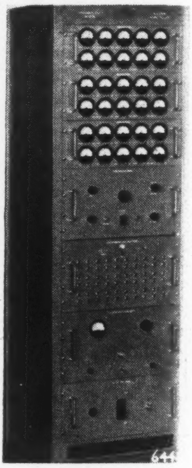
FM TELEMETRY TERMINALS

New "Model 1025 Telemeter Transmitter" and "Model 1090 Telemeter Receiver" will accurately and instantly telemeter measureables which can be converted into dc millivolts. Transmitter converts dc millivolts to an ac signal which in turn frequency-modulates an included audio-tone channel. Receiver converts audio tones to dc millivolts which can then be used to operate a recorder or indicator. Included channeling equipment assures accurate and reliable telemetering over all communication channels. At least 45 individual channels are available in frequency range of 765 cps to 20 kc. Both ac (10 to 30 cps) and relay outputs are available for transmission over low-cost lines.—*Radio Frequency Labs., Inc., Powerville Rd., Boonton 14, N. J.*



For more information circle **336** on inquiry card.

DECOMMUTATION STATION

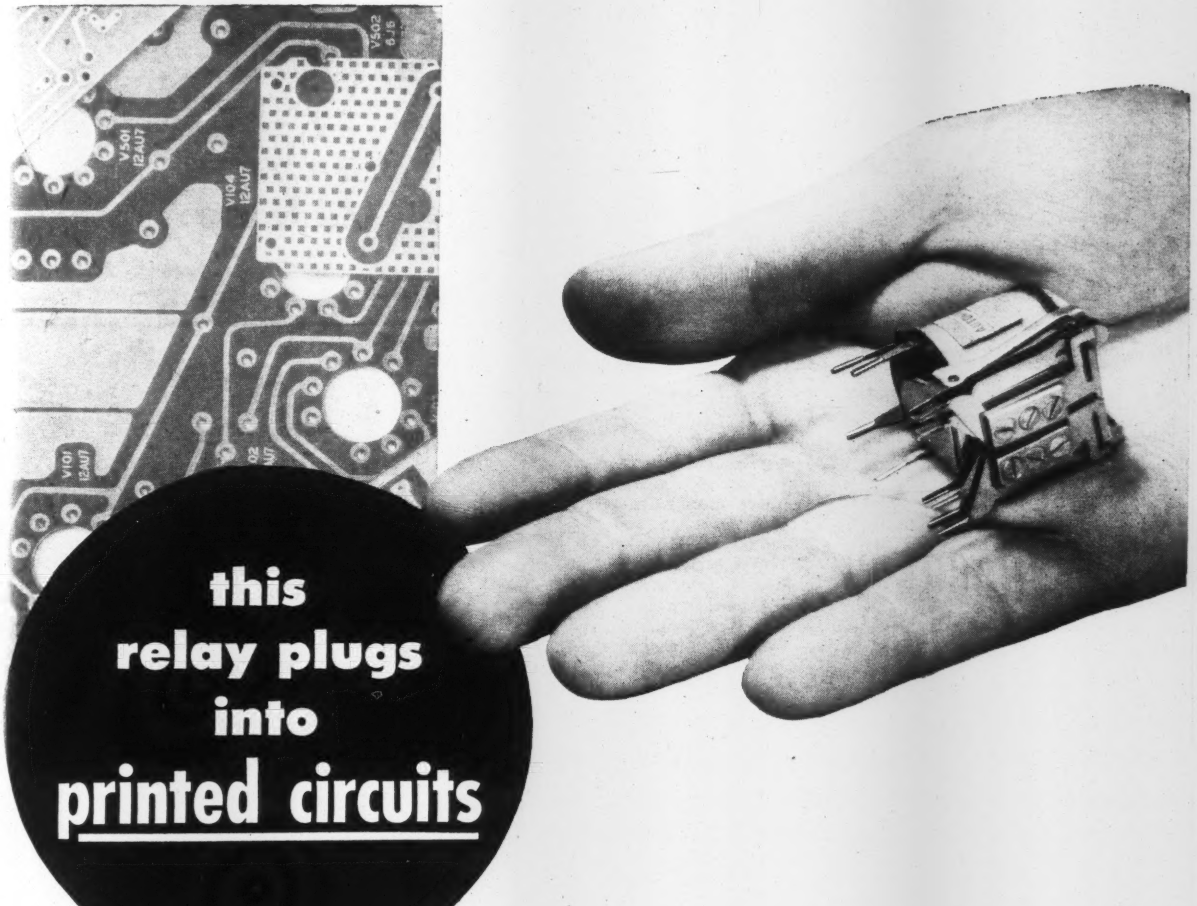


New single-rack "Telemetry Decommutation Station" handles both FM/FM and PWM data. Over-all system accuracy in linearity and stability is guaranteed to 0.5%. Thirty data demodulation channels have independent zero level and gain controls with output meter showing channel data level. Automatic zero-level drift and full-scale drift compensation on all channels, hence system essentially free of drift. —*Ralph M. Parsons Co., 135 W. Dayton St., Pasadena, Calif.*

For more information circle **337** on inquiry card.

TELEMETERING TRANSMITTER

New "Model 7501 Crystal Stabilized FM Transmitter" weighs 26 oz; features 3 watts of rf output throughout



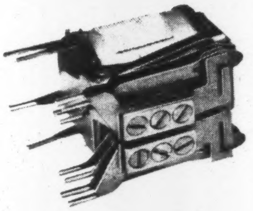
this relay plugs into printed circuits

. . . and runs up to 120 million operations without attention.

A new stainless-steel armature bearing pin, a new sintered metal yoke, a new lubricating system for the armature—these features add up to 10 times the life of former relays. Automatic Electric Printed-Circuit Relays meet today's needs in automation, in computers, in any applications requiring utmost dependability.

Specially designed plug-in terminals are an integral part of the coil and of the contact springs. They make firm, tight, high conductivity connections with printed circuits—and may be permanently secured by using any recognized soldering technique.

Besides these features, you get efficient magnetic design, permanently welded contacts, "stay-put" contact springs and many other advantages found in all Automatic Electric relays. Save parts, assembly and wiring time by using printed circuits—and Automatic Electric Printed-Circuit Relays. For complete details, *write:* Automatic Electric Sales Corporation, 1033 West Van Buren Street (HAymarket 1-4300), Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*



HELPFUL INFORMATION FOR THE TECHNICALLY MINDED . . .

Dimensions: Length, 1¾"; height, 1$\frac{5}{16}$" to 1¾" (depending upon the number of contact springs); width, 1".
Operating Voltage: Up to 175 volts, dc, only.
Contact Spring Capacity: Maximum of 9 springs per pile-up.
Springs: Can be made of phosphor-bronze, "Bronco" metal, or other special purpose materials, as required.

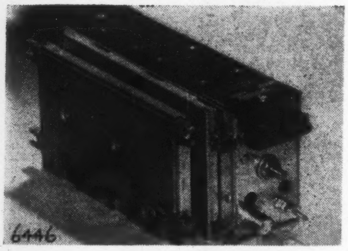
AUTOMATIC ELECTRIC®
ORIGINATORS OF THE DIAL TELEPHONE

GENERAL SYSTEM

For more information circle **77** on inquiry card.

telemetry band; carrier frequency held within 0.005%; frequency response maintained at 1.5 db between 100 cps and 1 Mc; 2% maximum modulation distortion; spurious rf output below 30 db; low sensitivity to vibrations, shocks, temperature variations, etc.—*Ralph M. Parsons Co.*, 135 *W. Dayton St., Pasaedna, Calif.*

For more information circle **338** on inquiry card.



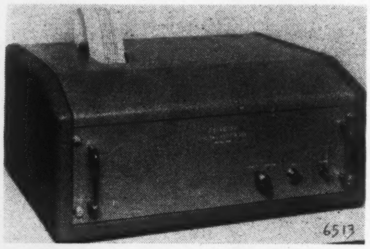
COMPUTING, DATA PROCESSING

STABILIZING AMPLIFIER

New "Model K2-P Stabilizing Amplifier" is designed especially for stabilizing operational amplifiers such as maker's "Models K2-W and K2-X" in electronic analog computing applications: it reduces already-low drift rate (5 mv per day) to submillivolt levels. Its gain of 1000 at dc allows extremely accurate solutions in an analog assemblage.—*George A. Philbrick Researches, Inc.*, 230 *Congress St., Boston* 10, *Mass.*

For more information circle **339** on inquiry card.

DIGITAL RECORDER



New "Model 1452" combines scanner and printer; operates directly from any late-model Berkeley counting equipment; prints readouts up to ten digits in arabic numerals on ordinary adding machine tape; can be modified to print "time" or "code" information on the same tape.—*Berkeley Div., Beckman Instruments, Inc.*, 2200 *Wright Ave., Richmond* 3, *Calif.*

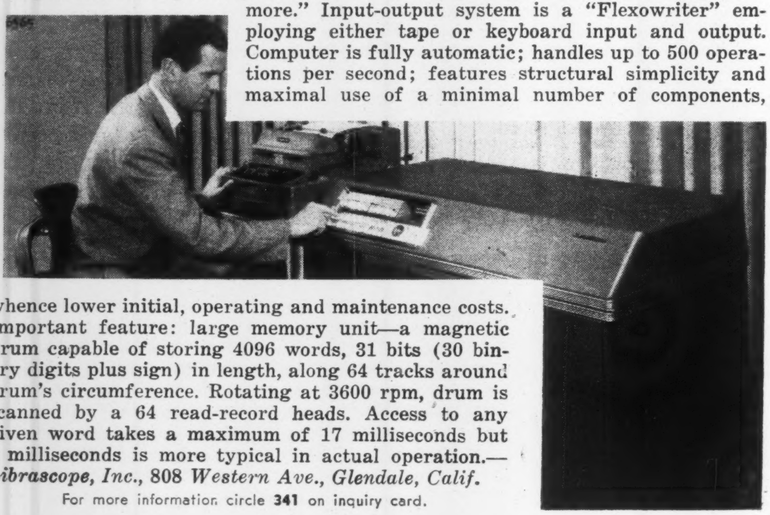
For more information circle **340** on inquiry card.

COMPUTER TIME SCALE CHECK

New "Time Scale Check," offered as an optional accessory on all "400 Series REAC" computers, permits eliminating errors due to computer components' frequency limitations (i.e., if time scaling is such that any

GENERAL-PURPOSE COMPUTER

New "LGP-30" portable desk-size computer is said to have "memory capacity and problem-solving ability of computers vastly greater in size and costing much more." Input-output system is a "Flexowriter" employing either tape or keyboard input and output. Computer is fully automatic; handles up to 500 operations per second; features structural simplicity and maximal use of a minimal number of components, whence lower initial, operating and maintenance costs. Important feature: large memory unit—a magnetic drum capable of storing 4096 words, 31 bits (30 binary digits plus sign) in length, along 64 tracks around drum's circumference. Rotating at 3600 rpm, drum is scanned by a 64 read-record heads. Access to any given word takes a maximum of 17 milliseconds but 2 milliseconds is more typical in actual operation.—*Librascope, Inc.*, 808 *Western Ave., Glendale, Calif.*



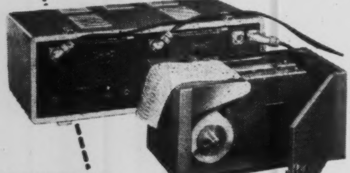
For more information circle **341** on inquiry card.

TYPE M CONSOLE
high-speed, absolute stability—up to six channels—microvolt sensitivity.

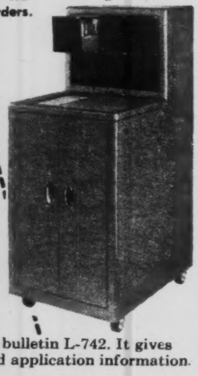
3 OFFNER DYNOGRAPH RECORDERS

Zero drift at all times.
Response speed—1/120 second.
Sensitivity 15 μv per mm.
Large easy-to-read records.
Isolated, differential input.
Thirty second warm-up time.

Write today for details or demonstration.



TYPE P PORTABLE
One or two channels. Same speed, sensitivity, and stability as Console Recorders.



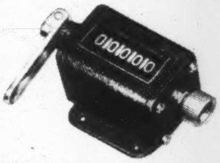
NEW
TYPE MC
Designed especially for write-out of analog computers, telemetering, and other low-gain applications.

Ask for bulletin L-742. It gives details and application information.

OFFNER ELECTRONICS INC.
5326 N. Kedzie Avenue, Chicago 25

For more information circle **78** on inquiry card.

Here's THE basic V-R "COUNTER-PACKAGE" for INDUSTRY...



SMALL RESET COUNTER

A compact, rugged reset counter for moderate duty in parts inspection, quality control, conveyors, machine tools, light presses, etc.

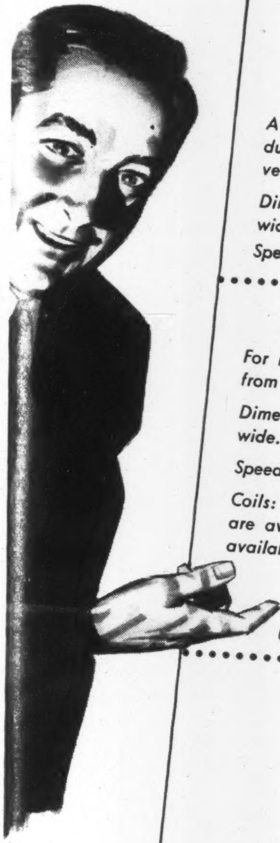
Dimensions: 1¾" long, 1¹⁹⁄₆₄" high, 1⁷⁄₁₆" wide

Speed: Up to 1000 counts per minute.

BOX-TYPE RESET COUNTER

For punch press installations, conveyors, metal-working equipment, die casting, plastic-molding, rivet, spring and wire machining, or any installation requiring a heavy duty counter.

Dimensions: 4¼" long, 2⁹⁄₃₂" high, 3⅜" wide.
Speed: 500 counts per minute.



RESET MAGNETIC COUNTER

For remote indication of machine operation from plant to office.

Dimensions: 3¹⁵⁄₁₆" long, 2½" high, 1⅝" wide.

Speed: Up to 1000 counts per minute.

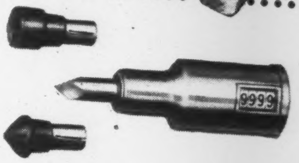
Coils: 110V-AC are standard. Other voltages are available. Panel mounting feature also available.

HAND TALLY

For quick spot-checks of production or performance.

Dimensions: 1¹⁷⁄₆₄" long (to end of reset knob), 1¾" deep, 2" high.

Counts one for each depression of the thumb lever, and resets to zero by a turn of the knob.



CLUTCH SPEED COUNTER

For checking to make sure that the machine is operating at the required R.P.M.

Dimensions: 3¼" long, ⅞" max. diameter. Non-Reset.

Internal clutch operates counter only when rubber tip is pressed against the shaft.

Here are 5 of the most widely used Veeder-Root Counters in industry . . . and they're immediately available from stock at leading Industrial Supply Distributors. There are Veeder-Root mechanical, electrical and manual counters for use in production recording and control, wage payment, time study work, quality control. In fact, you can profitably apply Veeder-Root Counters to every machine, operation, process or system in your plant. Ask your own Industrial Supply Distributor. Or write Veeder-Root Inc., Hartford 2, Conn.

Everyone can count on
VEEDER-ROOT
'The Name that Counts'

Insist on Standard
VEEDER-ROOT COUNTERS
from your
Industrial Supply Distributor
or write us on special problems

For more information circle **79** on inquiry card.

Visit our booth, No. 1126, ASTE Industrial Exposition, Chicago

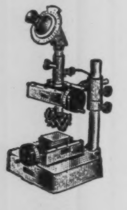
Toolmakers' Microscope

Ultimate in measuring microscopes. Range 2" x 4", reading to 0.0001", angular measurement to 1 minute.

Precise measurement to 0.0001"

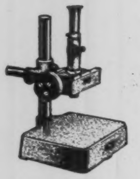
Slash rejects, save money with Gaertner measuring microscopes

Precise, versatile, easy-to-use Gaertner measuring microscopes assure positive, direct measurement of precision parts. You see clear, sharply-defined images. No physical contact to distort or injure object being measured. Enjoy new production savings with Gaertner optical instrumentation. Write for complete data on the Gaertner line of industrial microscopes.



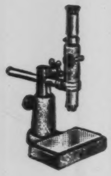
Coordinate Measuring Microscope

High precision, low cost instrument for 2-dimensional linear measurement. Range 2" x 2", reading to 0.0001".



Micrometer Slide Comparator

Reliable, low cost instrument for linear measurement. Ranges up to 4", reading to 0.0001" or 0.00005".



Scale Micrometer or Shop Microscope

High quality, low cost instrument with range up to 0.100". Reading to 0.001", easy interpolation to 0.0002".

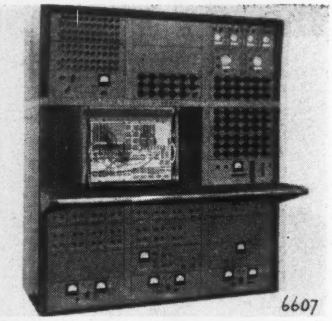
Write for Bulletin 161-54 showing applications, models, specifications.

The Gaertner Scientific Corporation

1211 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

For more information circle **80** on inquiry card.

component is operating beyond its frequency range, an error will be introduced into solution). New check is extremely simple to perform: (1) Problem is run once in normal fashion; (2) "Time Scale Check" switch is thrown to "half-speed" position; (3) problem is pre-run at exactly one-half former speed; (4) corresponding points on the two solutions are compared.—*Reeves Instrument Corp.,* 215 *E.* 91*st St., New York City.*



For more information circle **342** on inquiry card.

AVIATION

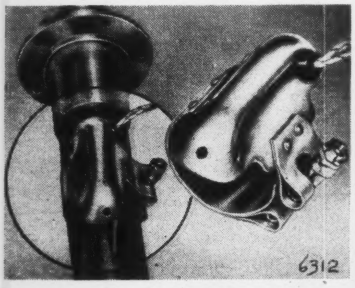
INTAKE-DUCT RAKES

New centrifugally-cast turbo-jet intake-duct rakes have been tested up to 1000 *G* in vibration at their first resonant frequency (about 300 cps). Several million cycles showed that integral stainless steel tubes increase rake's structural integrity about 400% above fatigue of aluminum portion, so that visual inspection can be a guarantee of strength. Available in any desired configuration with temperature, static-pressure, total-pressure or Pitot heads.—*Propulsion Development Labs.,* 1120 *El Segundo Blvd., El Segundo, Calif.*

For more information circle **343** on inquiry card.

FUEL LEVEL SWITCH

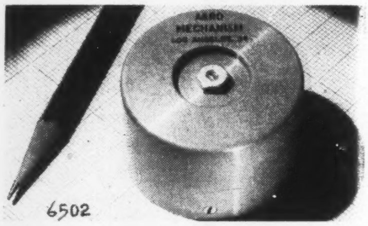
New liquid level switch can be used with any fuel gage to provide level control for tank switching, balancing and other fuel management functions; utilizes "Thervel" switch, features a "piggy-back" sensor that clamp-mounts on fuel tank probes without alteration to existing equipment. System has thermistor type sensing element and external control unit incorporating a bridge circuit and sensitive relay for operation of pumps, valves or warning lights. Operation of level switch is independent of fuel gaging equipment.—*Avien, Inc.,* 58-15 *Northern Blvd., Woodside, N. Y.*



For more information circle **344** on inquiry card.

MINIATURE ALTITUDE SWITCH

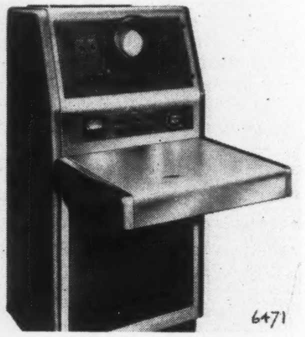
New miniature light-weight sp-dt 10-amp pressure switch actuates on small changes in altitude; can be set to operate anywhere in 2,000-50,000-ft range with an accuracy of better than 2% of range setting;can be obtained as an absolute ambient or as an absolute or differential pressure switch with standard fittings.—*Aero Mechanisms, Inc., Dept.* IA-6, *Box* 34628, *Los Angeles, Calif.*



For more information circle **345** on inquiry card.

H-F DIRECTION FINDER

New "Servoflight Model DFG-2R5" remote-control high-frequency direction finder minimizes problem of operation: antenna site and airport control tower can be as much as five miles apart. Tower operator could continuously monitor the bearings of all aircraft in HF communication with him. Equipment also provides position fixes (in conjunction with at least one more HF/DF station) and supplements surveillance radar



It's in the Bag!

Fresh, Clean Ink for a Year of Trouble-free Recording

★ You won't have any messy, time-consuming re-inking of pens on the new Bailey Recorders. The entire system is white-glove clean—hermetically sealed, non-evaporating, non-corrosive. Gone is any chance of sludge or oxide formation. Gone are clogged pens, interrupted records, unsightly splashes.

The transparent plastic ink sacs are changed once a year—that's all. Capillary tubing carries fresh, clean ink to the pens continuously without any day-to-day attention.

This exclusive new inking system* is only one of the many time-saving, money-saving distinctive features of the new Bailey Recorder.

Ask for Product Specification E12-5.

P34-1

*Now available for the New Bailey Recorder only.

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers—or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster ordering—from stock
- Minimum inventory of parts
- Minimum instrument investment for process cycle expansion or alteration

BAILEY
METER COMPANY
1041 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

BAILEY METERS

Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
RATIO DENSITY

For more information circle **81** on inquiry card.

PALMER

presents

an outstanding
improvement in

DIAL THERMOMETERS

CASE CAN BE ROTATED TO ANY READABLE POSITION
PALMER
°F
PALMER THERMOMETERS, INC. CINCINNATI, O. U.S.A.
Direct Drive
Mercury Actuated

external
calibration

Full 3½" Dial Face

- No Sector
- No Pinion
- No Linkage
- Constant Accuracy
- Easy Readability

Consult Your Classified Directory

WRITE FOR BULLETIN 350

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording
and Dial Thermometers

For more information circle **82** on inquiry card.

NEW INSTRUMENTS

with HF radio long-range capabilities.—*Servo Corp. of America*, 20-20 *Jericho Turnpike, New Hyde Park, L. I., N. Y.*

For more information circle **346** on inquiry card.

TANK UNIT TESTER

New "Model 1617-040" provides all necessary instrumentation for checking calibration accuracy and electrical insulation qualities of fuel gage tank units regardless of manufacturer or aircraft application; needs no correction cards or interpolations. Three ranges (0-100, 0-1000 and 0-5000 uuf) permit checking single tank units or complete fuel gage systems.—*Avien, Inc.*, 58-15 *Northern Blvd., Woodside* 77, *N. Y.*

For more information circle **347** on inquiry card.

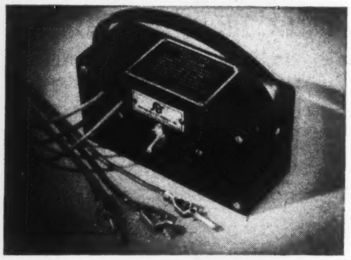
DRUM ACTUATOR

New lightweight linear drum actuator for trim tab control, originally designed for the "Helio Courier," is compact, light-weight and low-cost. Drum's 16 turns provides 2" of linear travel with 1/16" dia cable. A threaded boss on drum centerline provides a pick-up for a flexible control, or actuator can be used direct. Assembly also contains pick-up for position indicator.—*Avionic Products Engineering Corp., Route* 46, *Dover, N. J.*

For more information circle **348** on inquiry card.

MAGNETO TIMER

New "Model A-100 Timing Light" was developed especially for interna timing of magnetos and synchronizing magnetos to aircraft engines; not only has two neon lamps easily visible in daylight but also a buzzer whose sound changes in pitch as lights go on and off.—*Advanced Electronics, Inc., Rocky Hill, Conn.*



For more information circle **349** on inquiry card.

NUCLEONICS

RADIATION ANALYZER FOR GAMMA RAY SPECTROMETRY

New "Model 1810," used with a scaler or ratemeter and scintillation counter, makes possible highly precise measurements of gamma-emitting radioactive samples. An adjustable "window" on Analyzer can be set so that only those pulses that fall within a preselected portion of the isotope's energy spectrum are counted, thus virtually eliminating background and scattered radiation from final count. In addition, it permits multiple tagging measurements and radioisotope energy analysis.—*Nuclear Instrument & Chemical Corp.*, 229 *W. Erie St., Chicago* 10, *Ill.*

For more information circle **350** on inquiry card.

CLASSROOM COUNTER

New "Cenco Radioactivity Demonstrator" provides triple indication of radioactivity: by speaker, flashing light, and built-in count-rate-meter. Accompanying instruction manual describes experiments and provides examination questions and answers.—*Central Scientific Co.*, 1700 *Irving Park Rd., Chicago, Ill.*

For more information circle **351** on inquiry card.

HEALTH MONITOR

New "Model CS-40" is also referred to as the "Powder Puff Cutie Pie," i.e. the high-level portable monitor

TO: Department Heads and Supervisors

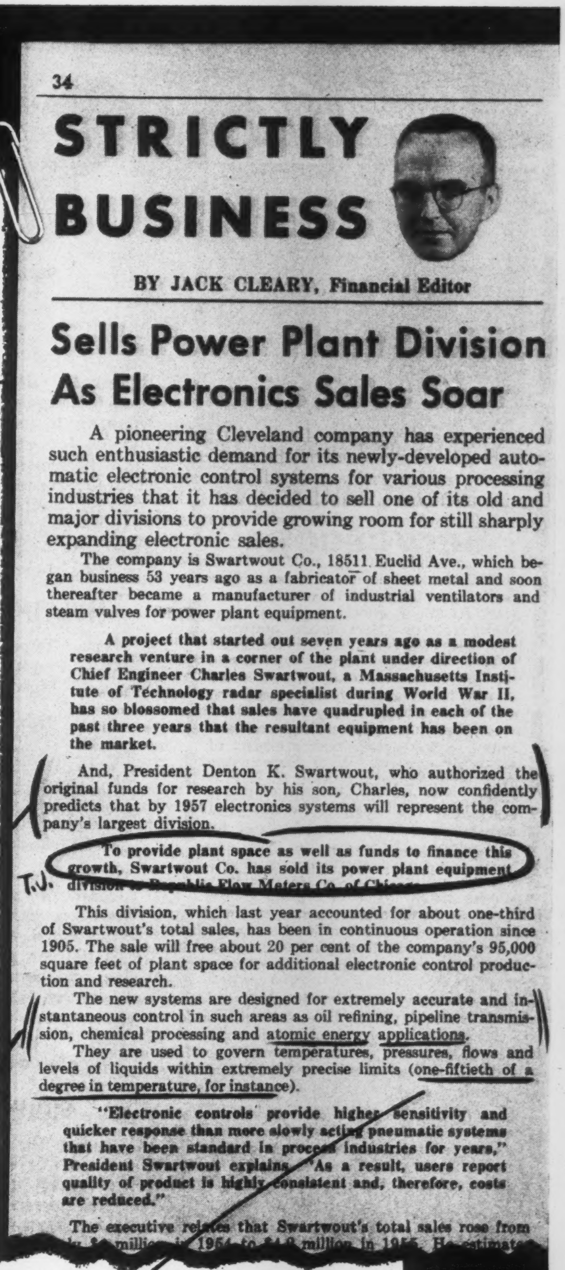
FROM: Vice President--Operations

The attached clipping from the CLEVELAND NEWS is of unusual interest. Your reaction and comments are solicited.

The writer has followed with great interest developments in electronic process controls since Swartwout first introduced the AUTRONIC SYSTEM. It is my belief that electronic controls make good, hard-headed business sense from both the quality-control and product-cost viewpoints.

It seems that Swartwout has streamlined its operations and is now in the electronic controls business to stay.

E. J. B.



34

STRICTLY BUSINESS

BY JACK CLEARY, Financial Editor

Sells Power Plant Division As Electronics Sales Soar

A pioneering Cleveland company has experienced such enthusiastic demand for its newly-developed automatic electronic control systems for various processing industries that it has decided to sell one of its old and major divisions to provide growing room for still sharply expanding electronic sales.

The company is Swartwout Co., 18511 Euclid Ave., which began business 53 years ago as a fabricator of sheet metal and soon thereafter became a manufacturer of industrial ventilators and steam valves for power plant equipment.

A project that started out seven years ago as a modest research venture in a corner of the plant under direction of Chief Engineer Charles Swartwout, a Massachusetts Institute of Technology radar specialist during World War II, has so blossomed that sales have quadrupled in each of the past three years that the resultant equipment has been on the market.

And, President Denton K. Swartwout, who authorized the original funds for research by his son, Charles, now confidently predicts that by 1957 electronics systems will represent the company's largest division.

To provide plant space as well as funds to finance this growth, Swartwout Co. has sold its power plant equipment ~~division to Republic Flow Meters Co. of Chicago.~~

T.J.

This division, which last year accounted for about one-third of Swartwout's total sales, has been in continuous operation since 1905. The sale will free about 20 per cent of the company's 95,000 square feet of plant space for additional electronic control production and research.

The new systems are designed for extremely accurate and instantaneous control in such areas as oil refining, pipeline transmission, chemical processing and atomic energy applications.

They are used to govern temperatures, pressures, flows and levels of liquids within extremely precise limits (one-fiftieth of a degree in temperature, for instance).

"Electronic controls provide higher sensitivity and quicker response than more slowly acting pneumatic systems that have been standard in process industries for years," President Swartwout explains. "As a result, users report quality of product is highly consistent and, therefore, costs are reduced."

The executive relates that Swartwout's total sales rose from [illegible] million in 1954 to [illegible] million in 1955. He [illegible]

They seem to be in it with both feet now that their production problems have been licked
LLM.

Looks like they mean business—Keep your eye on Swartwout

This is something we ought to look into
K.H.

Real cost savings here for our Eastern Plant!
R.S.

AA-2905

AUTRONIC
THE SWARTWOUT COMPANY
18511 EUCLID AVENUE
CLEVELAND 12, OHIO

For more information circle **83** on inquiry card.

An Engineer Speaks Out...

...about the NEW Servoscope®

There's a new look about the Servoscope multiple signal generator. At the request of many engineers who use Servoscope continuously in their work, we've redesigned the face panel . . . human-engineered the dials, switches and information display to reduce fatigue and increase accuracy.

Servoscope saves valuable man-hours in the design and analysis of servo equipment. With Servoscope you have a direct method for measuring gain and phase shifts of any component or system in the subsonic frequency ranges. Just by turning the big phase dial, you can read the phase shift of the servo-system under test. Servoscope generates three types of signals – sine wave, modulated carrier, and square wave.

Servoscope is an extremely versatile test instrument. Its applications range from automatic flight control design to testing computer response, checking vibration, and simulating rate gyro.

For the full story on Servoscope, please fill in your name and title in the section below. Attach it to your company letterhead and mail it on to me.

Thed P Westover

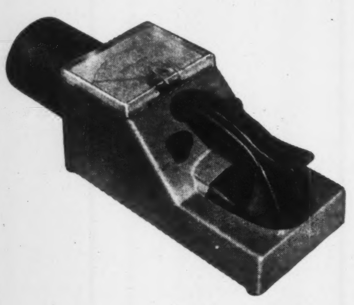
Chief Control Systems Engineer

Electro-mechanical Control Systems and Components for Industry by

SERVO CORPORATION OF AMERICA

Tom Westover, Dept. W-2
Servo Corporation of America
20-20 Jericho Tpke.,
New Hyde Park, L. I., N. Y.
Please send me more information on Servoscope.
Name ....
Title ....

For more information circle 84 on inquiry card.

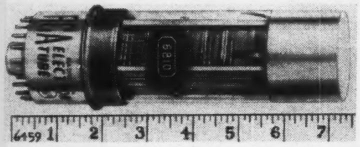


originally designed for Brookhaven Labs. Ranges 0.02, 0.2, 2, and 20 r/hr, making it usable even at diagnostic levels. Ion chamber can be discarded and inexpensively replaced if contaminated; resembles container in which powder puffs are often sold, whence name.—*NRD Instrument Co., 6429 Etzel Ave., St. Louis 14, Mo.*

For more information circle **352** on inquiry card.

MULTIPLIER PHOTOTUBE

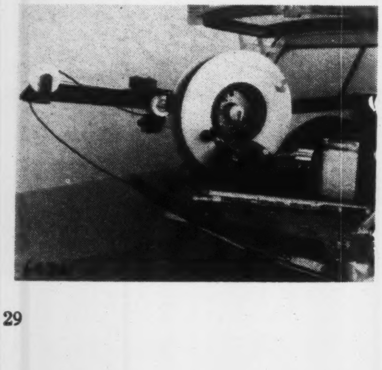
New "Type 6810" 14-stage head-on multiplier phototube features fast response, high current gain, relative freedom from after-pulse, and small spread in electron-transit time; is therefore particularly useful for fast-coincidence scintillation counting. It can deliver pulse currents up to 0.5 amp without appreciable deviation from linearity.—*Tube Div., Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.*



For more information circle **353** on inquiry card.

SURVEY EQUIPMENT

New "Gamma Logger" is a complete motor-driven scintillation counter logging unit designed for professional prospectors and mining engineers. It comprises a power-driven reel and extending arm, an adjustable pitch-metering pulley which drives a footage counter and radiation-level recorder, and a stainless-steel probe housing scintillation counter. Can be mounted rigidly on a drill rig or supplied with a portable mounting base for installation on pickup truck, jeep or station wagon (shown). Exclusive circuit improvements eliminate common sources of error in severe-service measurements. All power for operating motor and recorder can be furnished by a 12-v automobile storage battery.—*Moran Instrument Corp., 170 E. Orange Grove Ave., Pasadena 3, Calif.*



For more information circle **354** on inquiry card.

PROSPECTING COUNTER

New "Model 2612L" portable Geiger counter for uranium prospecting features a sensitive Geiger probe which can be mounted in handle or removed for surveying crevices, drill holes, etc. Ranges 0.2, 2, and 20 mr/hr full-scale.—*Nuclear Instrument & Chemical Corp., 229 W. Erie St., Chicago 10, Ill.*

For more information circle **355** on inquiry card.

RESISTANT-GLASS PLANCHET

New "Model 101," made of Pyrex brand glass, can be used for alpha, beta, or gamma counting of almost all chemical and biological substances. Rapid heating for sample preparation is also possible. Frosted marking area on side provides a means of identifying samples or indexing planchet for reproducible positioning. Rounded interior cup shape assists in obtaining reproducible evaporation of radioactive solutions. Diameter of 0.990" close tolerance for snug fit into all standard 1" holders.—*Pacific Nuclear, 5439 Geary Blvd., San Francisco 21, Calif.*

Actual size
6575

For more information circle **356** on inquiry card.

COUNTER CONVERTER

New "Model PCC-14," announced as "the first completely self-powered proportional counter converter to be available commercially," converts any scaler into a proportional counter for

Constant-voltage power for thousands of measurements– *with*

MALLORY Mercury Batteries

Pocket-size pH meter uses 6 Mallory RM-12R cells for power.

TO GET sustained accuracy of measurements for long periods between replacements, be sure to use Mallory Mercury Batteries in your portable instruments.

These unique batteries have a constant-voltage, constant-current discharge that eliminates a major source of drift in calibration. They do not deteriorate during long periods of storage, even under extremes of temperature and humidity. Providing high milliampere-hour capacity in small volume, they make an ideal power source for use with transistors or in any instrument in which space saving is important.

Mallory Mercury Batteries are permanently sealed . . . cannot swell or leak. Their rugged design withstands high impact and acceleration.

A wide range of capacities and voltage ratings is available. Write to Mallory for complete technical information.

Radiation detector for Civil Defense use is powered by 5 Mallory RM-12R batteries and a Mallory M-412R unit.

Expect more . . .
Get more from

P. R. MALLORY & CO. Inc.
MALLORY

P. R. MALLORY & CO., Inc., BATTERY DIV., NORTH TARRYTOWN, N.Y.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

For more information circle **85** on inquiry card.

NEW INSTRUMENTS

measuring alpha and beta activities. It detects alpha and beta radiation of all energies; counts alpha activity alone even in presence of high-level beta activity, and beta activity in presence of alpha. Sensitivity is five to fifty times that of end window Geiger-Mueller tubes, and does not vary with time, temperature or humidity. Background count is lowest available in commercial devices.—*Nuclear Measurements Corp.*, 2460 *N. Arlington Ave., Indianapolis* 18, *Ind.*
For more information circle **357** on inquiry card.

SHOP EQUIPMENT

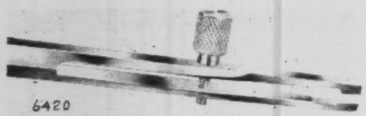
MIDGET TORQUE TOOL

New assembly tool can be preset in any range of ounce-inches, a wide range of gram-inches and a low range of pound-inches by a simple screw adjustment in handle. Wrench opening size can be specified when ordering. —*Apco Mossberg Co., Attleboro, Mass.*

For more information circle **358** on inquiry card.

SMALL-PARTS HOLDER

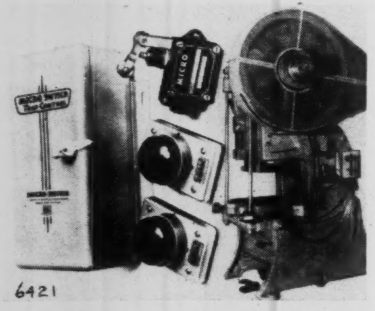
New "Micro-Vise" is described as a "third hand" for precision holding of miniature parts during assembly and inspection operations. Various sizes and mountings available for spot welding, soldering and other functions requiring use of both hands. Accurately-aligned smooth-locking-action jaws, in either square or needle nose. —*Micro Equipment Div., Dickinson & Assoc.* 557 *E. Walnut St., Pasadena, Calif.*



For more information circle **359** on inquiry card.

TWO-HAND CLUTCH CONTROL

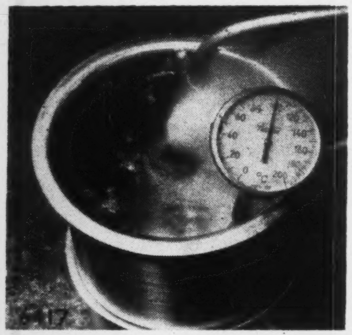
New "Micro Switch Trip Control" is an improved electric two-hand clutch control for industrial machines. It is said to make it possible to "increase productivity of manually-operated power machines by as much as 20%, besides assuring operator safety."—*Micro Switch, Freeport, Illinois.*



For more information circle **360** on inquiry card.

ULTRASONIC TRANSDUCERS

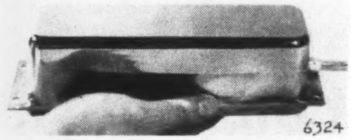
Newly improved barium titanate transducer markedly increases scope of application of hf ultrasonic equipment and makes possible low-cost ultrasonic processing at boiling temperatures; for example, use of hot cleaning solutions to speed ultrasonic cleaning of delicate or complicated parts. In addition, it minimizes effects of ultrasonic reflection in liquids of high viscosity.—*McKenna Laboratories*, 2503 *Main St., Santa Monica, Calif.*



For more information circle **361** on inquiry card.

ULTRASONIC CLEANING EQUIPMENT

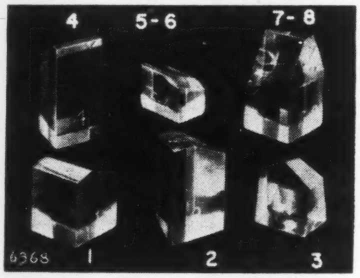
New hermetically-sealed ultrasonic power transducers and improved generators operating at 40 kc feature "sharply reduced cost" and versatile design opening up many applications previously considered impracticable or economically impractical. Illustrated example: "LF-15" transducer with radiating area of 2⅝" by 6"; modular design facilitating a wide choice of arrangements, including flush transducer banks, focussing and diverging.—*Branson Ultrasonic Co.*, 194 *Richmond Hill Ave., Stamford, Conn.*



For more information circle **363** on inquiry card.

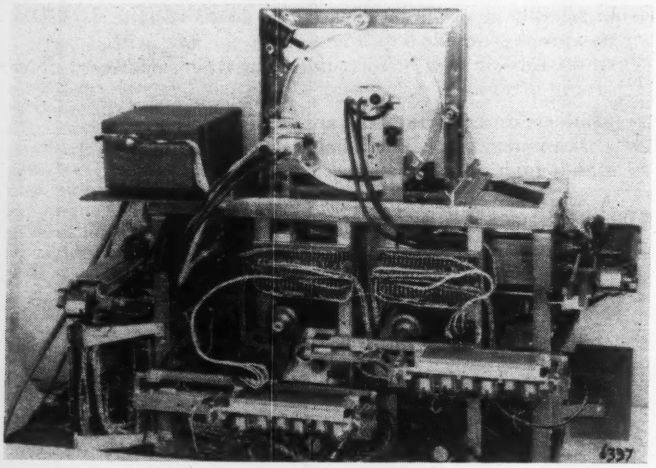
DIAMOND TOOLS

New diamond tools for machining small precision metal parts to extremely close tolerances, and for pro-

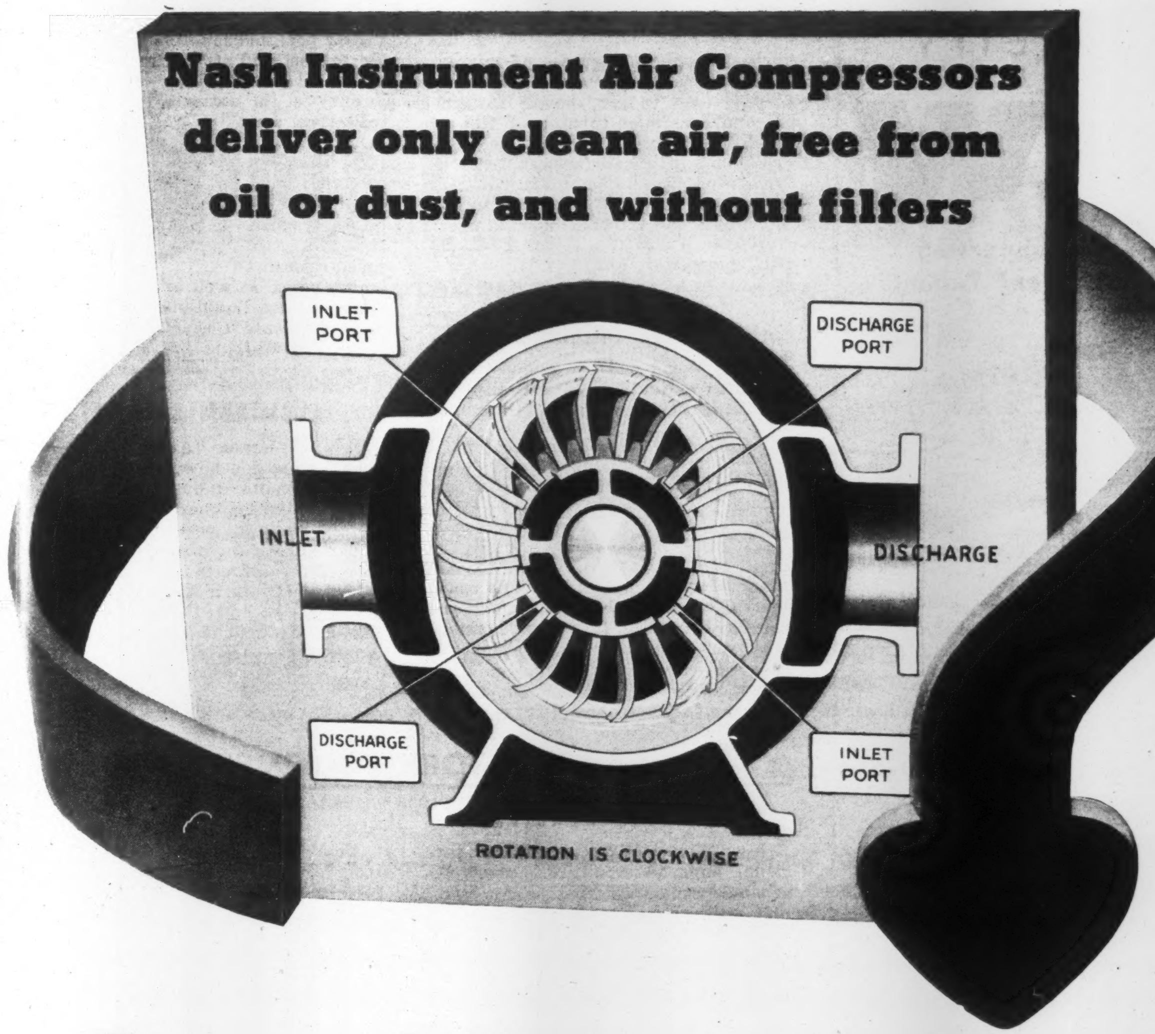


AUTOMATIC WIRE-WRAP WIRING MACHINE

New machine for automatic wiring between terminals on electrical chasis panels uses wire-wrap technique (developed by Bell Labs) for obtaining, without applying heat, an extremely reliable connection. Machine is controlled by punched tape. Wire panel size: 9¼" x 9¼"; module array 40 x 40 predetermined. Two carriages, each with *X* and *Y* motion; rotation stops at 90° points.—*Clevite Research Center*, 540 *E.* 105*th St., Cleveland, Ohio.*



For more information circle **362** on inquiry card.



Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

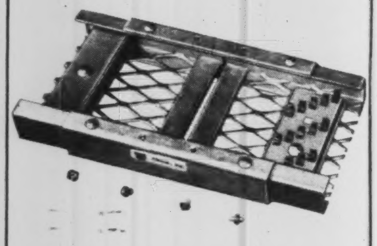
No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

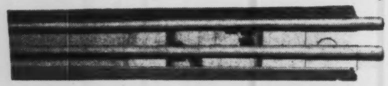
SPECIFY

P-W

for Supporting Instrument Tubing



P-W Manufactures a complete trough system with channel connectors. Drive rivets are used for quick assembly.—Extension Connectors eliminate field cutting—Adjustable connectors for any change in direction or elevation—I Section for long spans—Tube Clips—Cushion Clamps



Raceway to support a limited number of tubes with connectors, elbows, tees, etc.—Bulkhead Bar. P-W systems are available in widths from 1" to 24" and in lengths from 1' to 16'.

Twist-Rack

The Structure To Support Tubetrof . . . Cabletrof . . . Shelving . . . Conduit . . . Cables . . . Pipe, Etc.

Write today for Bulletin 955-D

P-W INDUSTRIES, INC.
Duncan & Melrose Sts.,
Philadelphia 24, Pa.

(Representatives to serve you!)

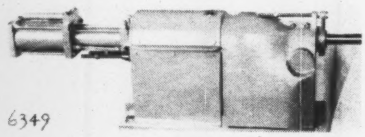
For more information circle 87 on inquiry card.

ducing machined surfaces of mirror-finish smoothness, comprise many turning tools (a few shown) for cut-off and for finish-turning of flat or bevelled surfaces; a series of laps for machining inside surfaces of holes to achieve precise diameter and fine finish; and a variety of discs and wheels for precision external machining.—*Hamilton Watch Co., Allied Products Div., Lancaster, Pa.*

For more information circle **364** on inquiry card.

AUTOMATIC DRILLING UNIT

New "Model 603" is a moderately-priced air-actuated hydraulically-controlled ½-hp automatic drilling unit which provides rapid advance to work, controlled feed through work and rapid retraction. It comes complete with induction motor and adjustable sheaves.—*The Electro-Mechano Co., 261 East Erie St., Milwaukee, Wis.*


6349

For more information circle **365** on inquiry card.

SAND-BLAST GUN

New portable sand-blast gun is simple to use: fill its 1-quart container with selected abrasive (or reflective material, etc., shot sizes 16 to 1000) and connect to air line. Useful in labs and instrument maintenance as well as in production. Also makes a liquid-blast gun.—*Lindberg Products Co., P.O. Box 855E, Los Gatos, Calif.*

For more information circle **366** on inquiry card.

ALUMINUM SOLDERS

New Hi-Grade "Alloys #175 and #101" were developed specifically for use in capacitor industry: addition of small controlled quantities of several metals made it possible to increase solder spread on aluminum, improve corrosion resistance and reduce drossing. "#175" is a free-flowing fast-acting alloy; "#101" is less fluid and can be used at a higher operating temperature.—*Hi-grade Alloy Corp., 7101 S. Stony Island Ave., Chicago, Ill.*

For more information circle **367** on inquiry card.

LABORATORY EQUIPMENT

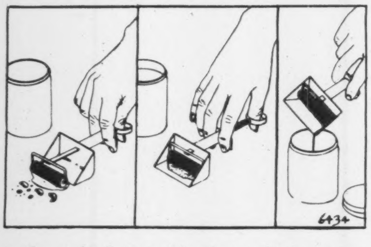
N-M-R GAUSSMETER

New "Model M-2 Numar" high precision gaussmeter utilizes principles of nuclear magnetic resonance. Thus, difficult problem of measuring magnetic fields is reduced to the more precise and easier problem of rf measurement, and absolute measurements with accuracies as high as 10 ppm can be obtained. System comprises rf oscillator, indicating oscilloscope, power supply, and four probes to cover range from 300 to 18,750 gauss. Weight 35 lb.—*Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **368** on inquiry card.

MERCURY SWEEPER

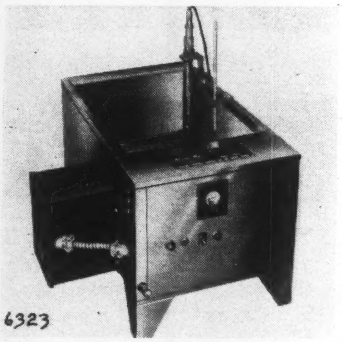
New device literally sweeps up spilled mercury by means of an amalgamated wire roller "magnet" and gathers it into a single pool; is especially useful on rough, dirty, or greasy surfaces.—*Chicago Apparatus Co., 1735 N. Ashland Ave., Chicago 22, Ill.*


6434

For more information circle **369** on inquiry card.

WATER BATH

New "Magni-Whirl" features control to 0.025°C and complete uniformity to 0.05°C; quick-set mercury thermoregulator and sensitive thyratron relay. Temperature range: room to 100°C.—*Blue M Electric Co., 138th & Chatham St., Blue Island, Ill.*


6323

For more information circle **370** on inquiry card

MICROMANIPULATOR

New "Catalog No. 51500 Cailloux Micromanipulator" will duplicate on a microscopic scale any possible movement that a hand will communicate to a single control lever. Design permits control lever to be placed in such a way that user's hand rests in a natural relaxed position. Magnifications 100 × to 2000 ×. Instrument corrects

ENGINEERS

NEW 2-FOLD
RETIREMENT INCOME PLAN

for Aviation and Missile Engineers

It's natural that a long-time leader in aviation, like Republic—with many firsts to its credit—should be a leader, too, in providing for the welfare of its staff. Right in line with this forward-looking policy is the remarkable new Republic Retirement Income Plan. Here is how it works:

PART 1 *is a basic Retirement Income plan paid for* entirely *by Republic Aviation.*

PART 2 *is a cooperative effort. It is completely optional. But if an engineer wishes to increase his retirement fund, by making a small monthly payment, Republic will* MORE THAN MATCH *his contribution.*

Take the case of a hypothetical engineer who joins Republic on January 1st, 1956, averages $8,000 a year for 15 years; then retires aged 65. If he elected PART 2 of the plan, he will have a total *monthly retirement income of $225.80,* including his social security. For this he himself will contribute *only $8.50 a month* to the Republic Retirement Income Plan.

Of course, the MORE YOU EARN, the HIGHER your Retirement Income will be. And Republic pays a top salary scale in the industry.

...RETIREMENT PLAN JUST ONE OF MANY PLUS FACTORS POINTING TO A REPUBLIC CAREER

FIRST — there's the interest and prestige of working for a pioneer in aircraft design, creator of such famous planes as the F-84 Thunderjet, the F-84F Thunderstreak, RF-84F Thunderflash and XF-84H. (Soon to be followed on the production line by the new F-103, F-105 and RF-105.)

SECOND —the company is expanding sharply, providing frequent opportunities for able men to advance. In fact a $12,000,000 increase in the Research and Development Program has just been announced.

THIRD —an All-Expense Paid Relocation Plan for qualified engineers living outside the New York City and Long Island areas, which makes it easy to move to Republic. Other liberal benefits: Life, Accident and Health Insurance; Hospital-Surgical Benefits for the whole family; educational aid covering ⅔ the cost of collegiate and graduate study.

Serve your own best interests. Make full inquiries into the many advantages of joining Republic now, not the least of which is living on Long Island—the Playground of the East.

Important engineering positions are now open at all levels:

STAFF ENGINEERING
PRELIMINARY DESIGN
ELECTRONICS
WEAPONS SYSTEMS PROPOSALS
OPERATIONS RESEARCH
SYSTEMS
MATHEMATICAL ANALYSES
AERODYNAMICS
TECHNICAL WRITING
DYNAMICS
ELECTRO-MECHANICAL DESIGN
FLIGHT TEST
RESEARCH
THERMODYNAMICS
FLUTTER & VIBRATIONS
STRESS
AIRCRAFT DESIGN
WEIGHTS
DESIGNERS:
Electrical
Airframe
Mechanical

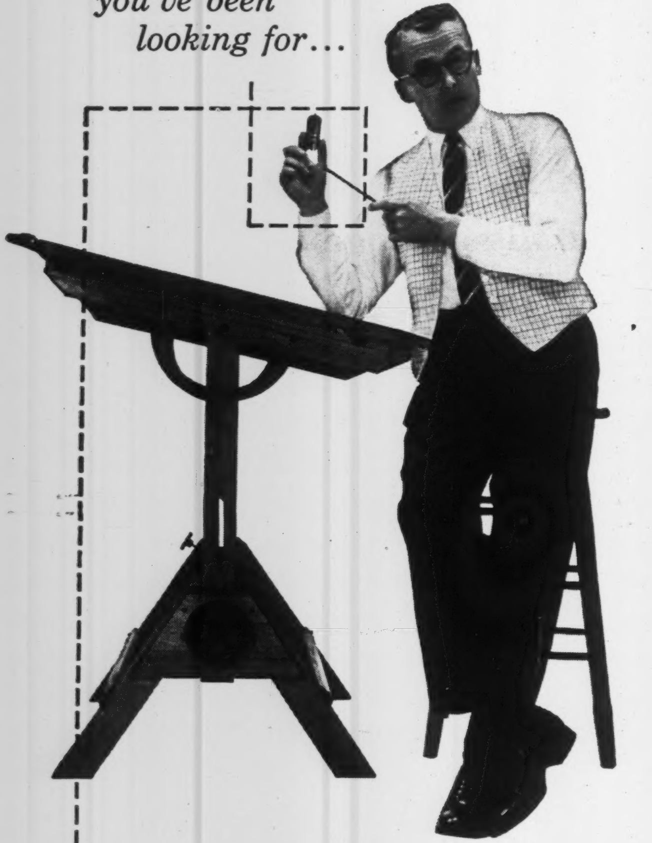
Please address complete resume
outlining details of your technical background to:

REPUBLIC AVIATION

AIRCRAFT
Assistant Chief Engineer, Administration, **Mr. R. L. Bortner**
Farmingdale, Long Island, N. Y.

MISSILES
Administrative Engineer, Mr. Robert R. Reissig
Hicksville, Long Island, N. Y.

Here's what
you've been
looking for...



A GEAR HEAD SERVO MOTOR WITH LOW INERTIA...LOW BACKLASH AND A BIG PLUS IN FLEXIBILITY!

Norden-Ketay engineers design quality precision components that meet all your requirements. By combining low inertia and low backlash with new flexibility in servo motor design, Norden-Ketay makes possible...

MAXIMUM GEAR RATIO VARIATIONS—from 5:1 to 10,000:1 by simply changing gear clusters.

MAXIMUM BACKLASH CONTROL—backlash restricted to less than 0° 30′.

MAXIMUM OUTPUT TORQUE—from 50 inch ounces to 150 inch ounces.

EASE OF MAINTENANCE—simplified design offers quick easy assembly and maintenance.

CORROSION RESISTANT—built to military specifications (MIL E-5272A).

AVAILABLE IN VARIOUS SIZES—11, 15, 18. Other sizes available on special order.

For complete details write for data file #143.

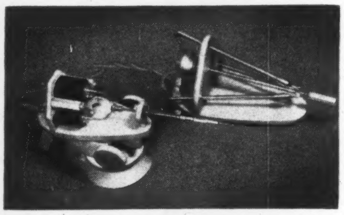
SERVO MOTOR
GEAR TRAIN
NORDEN-KETAY CORPORATION

NORDEN-KETAY CORPORATION

PRECISION COMPONENTS DIVISION:
555 Broadway, New York 12, N. Y.
WESTERN DIVISION:
13210 Crenshaw Blvd., Gardena, California

SYNCHROS · RESOLVERS · RESOLVER AMPLIFIERS · SERVOMOTORS · GEARED SERVOMOTORS · INDUCTION MOTORS · TACHOMETER GENERATORS · MAGNETIC INDICATORS · SERVO AMPLIFIERS · REMOTE INDICATING DEVICES · TACHOMETER INDICATORS · INDUCTION POTENTIOMETERS · ELECTROMECHANICAL DEVICES

For more information circle **88** on inquiry card.

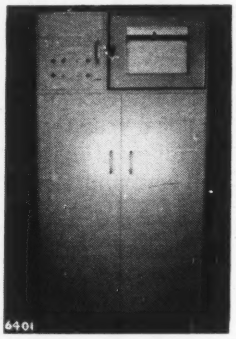


for reverse movements (optical inversion) normally observed under microscope; comes with six microtools.—*C. H. Stoelting Co.,* 424 *Nort Homan Ave., Chicago* 24, *Ill.*

For more information circle **371** on inquiry card

GAS ANALYZERS

New "70 Series Automatic Ga Analyzers" can be easily adapted t recording many different gases an

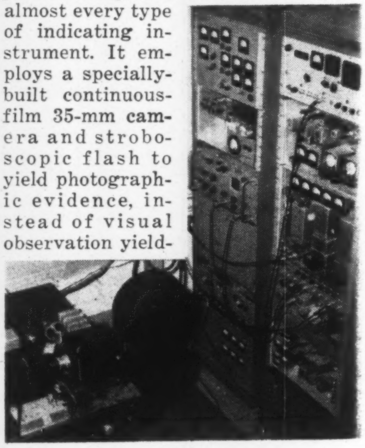

6401

vapors, as in air pollution surveys monitoring trace constituents, etc. U to three analysis systems can be incorporated in each unit. Glasswar panels are available for various flo systems.—*Harold Kruger Instruments, P. O. Box* 164, *San Gabriel Calif.*

For more information circle **372** on inquiry card

MULTIPLE-INSTRUMENT CALIBRATION SYSTEM

New "Automatic Calibrator" eliminates human drudgery in point-by-point testing, and data-recording, fo almost every type of indicating instrument. It employs a specially-built continuous-film 35-mm camera and stroboscopic flash to yield photographic evidence, instead of visual observation yield-

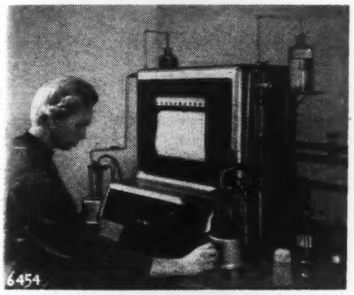


ing notebooks or manually-typewritten sheets. In calibrating frequency meters (as in photo), announcement states that "up to five channels of information can be put on the film simultaneously. . . . When frequency meters were calibrated by hand it took three people two weeks to make a single calibration. Now 5800 separate calibrations are done in less than 15 minutes." Claimed accuracy is "one part in 100,000."—*Lavoie Laboratories, Morganville, N. J.*

For more information circle **373** on inquiry card.

AUTOMATIC TITRATOR

Newly redesigned "Precision-Dow Dual Recordomatic Titrometer" is said o be the only instrument which actually titrates, automatically controlling the rate of reagent-feeding and automatically plotting titration curves." No manual plotting or manual incremental addition of titrant. Complete titration in 5 min or less. Accuracy 0.05 ml (one drop) of titrant, even with three or more end points.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*



For more information circle **374** on inquiry card.

HOMOGENIZER

New "VirTis 23" (23,000-rpm) homogenizer is a low-cost junior model which, though not as big and powerful as heavy-duty "VirTis 45," will handle most homogenizing procedures efficiently. It is equally effective for both micro and macro work; handles volumes from 0.2 to 200 ml. "Superior top drive design elim-

FOR JET POWER MEASUREMENT WITH UNRIVALED ACCURACY SPECIFY NORDEN-KETAY PRESSURE RATIO INDICATING SYSTEMS

Combining maximum reliability with light weight design... Norden-Ketay Pressure Ratio Indicating System provides you with the most accurate method of thrust measurement... assures you of optimum safety in take-off and fuel economy at cruise. The unique Transducer design is being applied to other aircraft instrumentation including: machmeters, high accuracy altimeters and air data systems.

EXTREME ACCURACY—±0.01 pressure ratio at room temperature; ±0.02 pressure ratio from −55°C to +70°C, ±.025 pressure ratio to 120°C.

HIGH RELIABILITY—withstands high over-pressures... eliminates hysteresis effects to insure long-life dependability. Operates at altitudes from 0 to 75,000 feet.

RUGGED DESIGN—will meet latest military and commercial requirements. Engineered for simplified maintenance. Exclusive floating disc suspension insures accuracy under environmental conditions of MIL-E 5272A.

FLEXIBILITY—three basic systems which can be adapted to your particular needs. Transducer withstands high temperatures and vibrations of engine mounting.

For complete details write for data file #143.

PRESSURE RATIO
35
40
30
25
20
15
10

NORDEN-KETAY CORPORATION

Instrument and Systems Division
Wiley Street, Milford, Connecticut

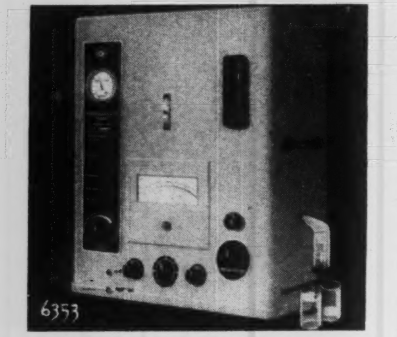
For more information circle **89** on inquiry card.

inates heat formation and does away with leakage problems."—*E. Machlett & Son, 220 East 23rd St., New York 10, N. Y.*

For more information circle **375** on inquiry card.

FLAME PHOTOMETER

New "Dr. Lange Flame Photometer," for chemical analysis, need only be connected to a 110-v to 240-v power supply and a suitable fuel supply; has a gas pressure compensator for feeding from a municipal gas supply; comes with five interference filters (rotative) for determination of up to ten elements. (Alternatively a band type interference filter can be supplied). Built-in compressor works without oil. Voltage stabilizer and a special dc amplifier of high sensitivity and constancy are also built in.—*European Products Importing Co., 154 Nassau St., New York 38, N. Y.*



For more information circle **376** on inquiry card.

SPECIMEN POLISHERS

New "Selecto-Speed" features speed infinitely variable from 100 to 1200 rpm while motor is running. In table models, speed is indicated on an illuminated screen on table top. Polishers are offered with 8″, 12″, or 16″ wheels, in 1-, 2- or 3-unit tables. ★New automatic polishing attachment for metallurgical specimens is a low-cost unit designed to fit maker's 8″ low-speed polishers; accommodates 6 mounted specimens of 1″ dia or 5 of 1¼″ dia. Polishing a group of specimens takes an average of 20 minutes.—*Buehler Ltd., 2120 Greenwood St., Evanston, Ill.*

For more information circle **377** on inquiry card.

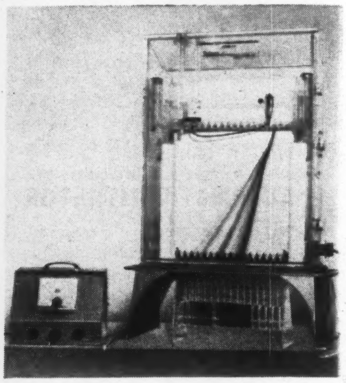
OXYGEN-ELECTRODE APPARATUS

New "KEL Recording Oxygen Electrode Apparatus" operates from ac line; can be used with most servo-recorders to measure relative changes of oxygen concentration in aqueous solutions. Sample can be as small as a milliliter. Temperature is monitored continuously. An inexpensive 4½″ non-recording indicator and a pumping temperature-controlled bath are available. Additional electrodes are mechanically and electrically interchangeable.—*Kilpatrick Electronic Lab., Box 61, Norristown, Pa.*

For more information circle **378** on inquiry card.

CONTINUOUS-FLOW PAPER ELECTROPHORESIS

New "Continuous-Flow Paper Electrophoresis Apparatus" features new methods of electrolyte feed and wide-range controls permitting instrument to give maximum throughput under any required degree of resolution. Moreover, resolutions formerly requiring as much as 1,500-v operation are made at ⅓ this value.—*Spinco Div., Beckman Instruments, Inc., 6[illegible]5 O'Neill Ave., Belmont, Calif.*



For more information circle **379** on inquiry card.

GAGING, MECHANICAL TESTING

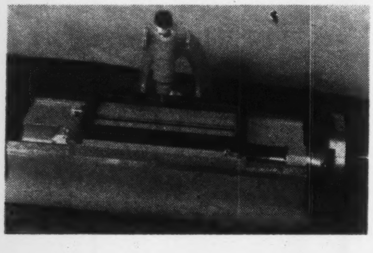
COATING-THICKNESS GAGE

New "Tinsley Thickness Gauge," for measuring thickness of non-magnetic coatings such as paints or plating on ferrous bases, will determine thickness on radii (irregular or curved surfaces present no problem); is not affected by vibration and temperature; will not damage coatings; has two scales—one for standard calibration for non-magnetic coatings on a mild steel base, and (on reverse side) a linear scale 0-10 units for special calibrations. Range 0.0002″ to 0.015″.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

For more information circle **380** on inquiry card.

MEASURING COMPARATOR

New "Model 100" features: (1) guaranteed accuracy of one micron in its 255-mm measuring length and readings to fractions of microns; (2) microscope with operator convenience as well as superior optics; (3) high-precision mechanical parts. Cross-slide motion is 102 mm. Over-all length 24½″; weight 90 lbs. Available also in English as well as Metric System.—*Paul H. McPherson, 527 Main St., Acton, Mass.*



For more information circle **381** on inquiry card.

INDUSTRIAL X-RAY UNITS

New "Baltospot" (illustrated) makes possible wider use of radiography in weld inspection; features extremely low weight-to-power ratio: x-ray head weights 46 lbs, provides 140 kvp for radiographing up to 1½″ steel or equivalent. X-ray head and control panel fit inside a trunk 32″ by 16″ by 13½″.★ New "Baltograph 180," an end-grounded unit with x-ray source at one end of head, enables

MOISTURE CONTENT

without involved computations!

Quickly and accurately determine the moisture content in any material—whether fibrous, granular, liquid or semi-liquid—with the DIETERT MOISTURE TELLER. No involved computations. No skilled help required!

he No. 276 Moisture Teller is a sturdy, versatile unit, equipped with a ıermostat having a range of 150 to 300°F. Ideal for drying an exceedingly ide range of samples. Drying temperature is controlled within 7 degrees f the selected temperature. The Moisture Teller may also be used as drying oven. A complete line of Dietert Moisture Tellers is available for esting all types of materials, including large bulky samples of wool, fibres, aper and textile products.

HARRY W. DIETERT CO. / *Control* **EQUIPMENT**

9330 Roselawn, Detroit 4, Michigan

For more information circle **90** on inquiry card.

FREE

INFORMATIVE BULLETIN

How to set new highs in precision measurement of low temperatures

a new high in low temperature measurement!

ALNOR Type 2300 Pyrometer

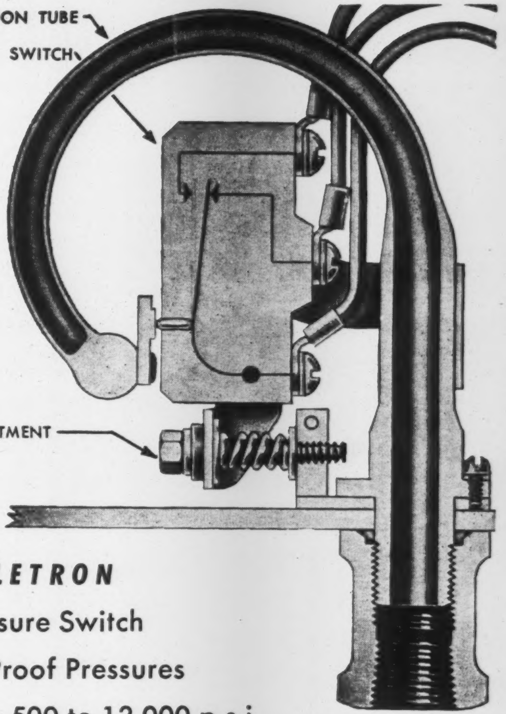
This special low-temperature Alnor Pyrometer is invaluable for balancing hot water heating systems, checking floor, wall or ceiling temperatures in panel heating systems, measuring temperature of refrigerated coils, insulation and all other low temperatures. Sturdy and completely portable, the Type 2300 can be taken anywhere—and give precise, direct readings in from 3 to 5 seconds.

Tear out this ad and attach it to your letterhead. Mail to Illinois Testing Laboratories, Inc., Room 518, 420 North La Salle Street, Chicago 10, Illinois.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **91** on inquiry card.



MELETRON

Pressure Switch for Proof Pressures from 500 to 12,000 p.s.i.

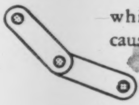
Competes on Price
Wins on Accuracy

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS



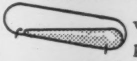
which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS



which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete operating characteristics and specifications ask for bulletins 302 to 382.

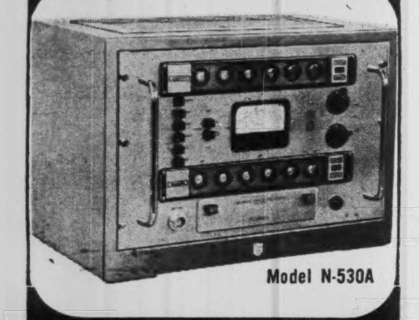
BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **92** on inquiry card.

AUTOMATIC ELECTRONIC
DECADE SCALER
AND TIMER
for optimum speed
and accuracy


Model N-530A

The simplicity and accuracy of Dekatron counting and timing circuits make the **Ekco Model N-530A** Automatic Scaler the most outstanding and most versatile instrument of its kind. This scaler will time a pre-determined count, count for a pre-determined time, or can be manually operated.

FEATURES:
- Preset elapsed time interval—100-100,000 seconds in 10ths
- Preset elapsed count interval—100-1,000,000 counts
- Maximum counting rate—60,000 counts second
- Maximum stopping time—2 milliseconds
- Six electronic decades
- Dekatron direct-reading counting and timing tubes
- Pulse height discriminator permits use with G-M, scintillation, flow or proportional counters—variable 5-50 volt preset acceptance level

SPECIFICATIONS:
- Imput sensitivity—negative 0.1 volt and positive 5 volts
- Input resolution time—5 microseconds, low coincidence loss
- Power Requirements—110-250v, 50/60 cycles, 130 watts
- Dual-range Power Supply—250-1000 and 500-2000 volts
  Stability—± 0.5% for variations up to ± 10%.
  Ripple—less than 5 mv. rms peak

Write TODAY to our American representative for technical data on the complete line of EKCO equipment.

EKCO
ELECTRONICS, LTD.
Southend-on-Sea,
Essex, England
U. S. Sales and Service
AMERICAN TRADAIR CORP.
Long Island City 6, New York

For more information circle 93 on inquiry card.

operator to reach otherwise inaccessible locations; is rated at 180 kvp; can be equipped with a tube for 360° radiation or with an angle target tube giving an output of 10 ma with an inherent filtration of ⅛" beryllium.★ New "Baltograph 260," rated at 260 kvp, provides high penetration power required in checking thick high-density metals.—*Balteau Electric Corp., New & Meadow Sts., Stamford, Conn.*

For more information circle **382** on inquiry card.

RUNNING-TORQUE METER

New "Model 40" is an all-electric calibrated torque source for measuring torque characteristics of small gear trains, servos, springs, clutches, etc. Range 0.05 to 40 oz-in with better than 5% over-all accuracy at shaft speeds from zero to 100 rpm. (Additional speed ranges special).—*Bulova Research & Development Labs., Inc.,* 62-10 *Woodside Ave., Woodside* 77, *N. Y.*

BULOVA
BULOVA
TOROMETER
6327

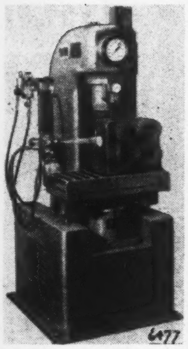
For more information circle **383** on inquiry card.

INSTRUMENT-BEARING-FRICTION-TORQUE METER

New "Mass Accelerator" embodies a new technique for measuring torque on ball bearings: A known inertia load is placed by hand (see photo) on outer race of bearing; inner race is rotated at a known speed in such a way that bearing-friction torque is the only force causing outer race to move. Torque is determined by number of inner race revolutions required to make outer race turn 360°.—*Burroughs Corp., Detroit 32, Mich.*

For more information circle **384** on inquiry card.

CONVEYER-LINE TYPE HARDNESS TESTER



New high-production-plant version of maker's Brinell Hardness Tester has a paint spray attachment tha synchronizes with machine's testing cycle so that relative hardness o parts is automatically indicate by a spot o paint. Tester i designed to fit into a roller conveyor (supplied by user). Parts ar rolled into place on roller section o Tester. Operator locates part, ther depresses the "cycle start" button t start machine's hydraulic cycle.—*Stee City Testing Machines, Inc.,* 8817 *Lyndon Ave., Detroit* 38, *Mich.*

For more information circle **385** on inquiry car

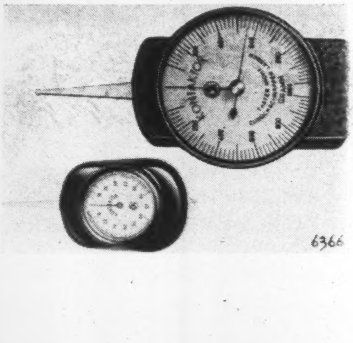
GEAR CHECKER

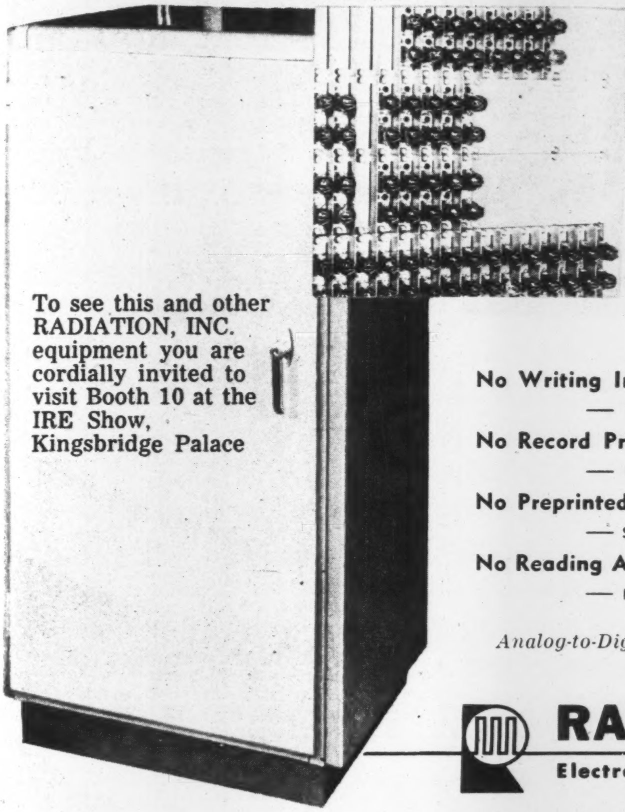
New "Model SIG Red Ring" gear checker fo inspecting spu or helical internal gears up to 18" pitch diameter checks tooth-to-tooth spacing, pitch or root diameter eccentricity and size as well as parallelism of spur gear from 2 to 48 diametral pitch having pitch diameter from 2" to 18".—*National Broach & Machine Co.,* 5600 *St. Jean Ave., Detroit* 13, *Mich.*

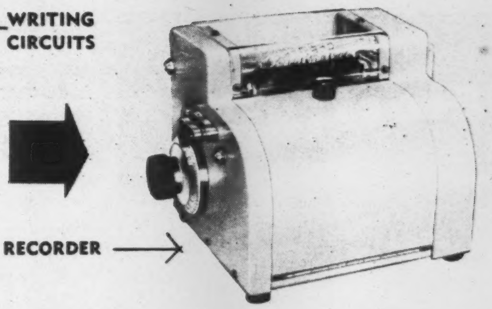
For more information circle **386** on inquiry car

DYNAMOMETERS

New "Kontaktor Gram Gauges," made in W. Germany, measure force between contact blades and points, o







To see this and other
RADIATION, INC.
equipment you are
cordially invited to
visit Booth 10 at the
IRE Show,
Kingsbridge Palace

ADAR*

No Writing Inertia
— high transient response

No Record Processing
— directly visible writing

No Preprinted Chart
— simultaneous scale writing

No Reading Aides
— naked eye reading to ±0.2%

Analog-to-Digital-to-Analog Recording — the new concept in analog recording

RADIATION Inc. Melbourne, Fla.
Orlando, Fla.

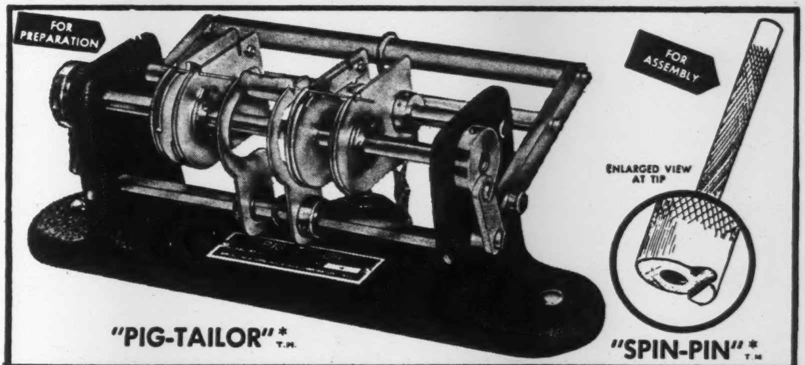
Electronics • Avionics • Instrumentation
Personnel Inquiries Invited

For more information circle **94** on inquiry card

"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.

● ● ● ● ●



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits
6. Individual cut and bend lengths
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

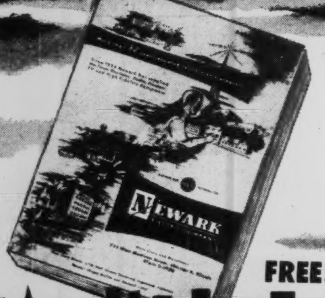
PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components.
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

PATENT PENDING ***Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. IA3-P***

BRUNO-NEW YORK INDUSTRIES CORPORATION
DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT
460 WEST 34th STREET • NEW YORK 1, N. Y.

For more information circle **95** on inquiry card.



See What's New in Electronics

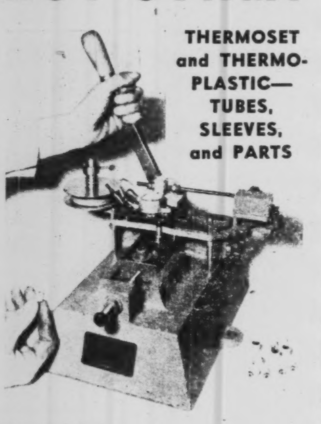
FREE!

Send for
NEWARK'S 1956 CATALOG
260 pages of the newest developments in test instruments, tubes, capacitors, transformers and everything you need in Electronics, Radio, TV, Amateur and High Fidelity.

NEWARK
ELECTRIC COMPANY
Dept. IN-3, 223 W. Madison, Chicago 6, Ill.

WEST COAST BRANCH
4736 W. Century Blvd., Inglewood, Calif.

For more information circle **96** on inquiry card.



HOT STAMP

THERMOSET and THERMO-PLASTIC—
TUBES, SLEEVES, and PARTS

IN COLOR—
ACROMARK Model 924AH is a duo-purpose marking machine that will do fast marking of small parts in metal and with the heat unit turned on it also marks plastics IN COLOR.

Write for Literature and prices upon Model 924A and 924AH machines.

The ACROMARK Company
3-11 Morrell Street, Elizabeth 4, N. J.
"The Original Marking Specialists"

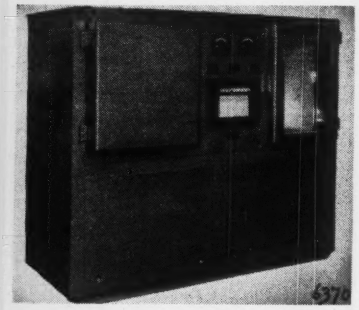
For more information circle **97** on inquiry card.

where springs, brushes, etc., exert measurable forces. Two sizes; various ranges from 2-15 grams to 200-2000 grams.—*Guardian Electric Mfg. Co.*, 1621 *W. Walnut St., Chicago* 12, *Ill.*

For more information circle **387** on inquiry card.

TEMPERATURE TEST CABINET

New environmental testing chamber permits simultaneous testing of two portions of an operating system: operating portion can be placed in one compartment and subjected to temperatures from −100°F to 200°F. Meanwhile, controlling instrumentation is isolated in another regulated chamber. New unit is thus well-suited for testing automatic control equipment and airborne systems.—*Harris Refrigeration Co.*, 365 *Walden St., Cambridge, Mass.*

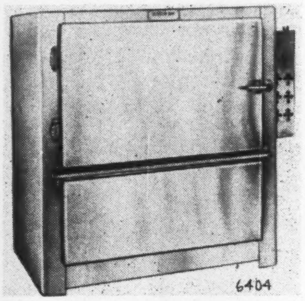


6370

For more information circle **388** on inquiry card.

ENVIRONMENT TEST CABINETS

Newly redesigned "Weather-Labs" are made in four sizes from 10 to 40 cu ft working space; temperatures from 30°F to 200°F and relative humidities from 20% to 95%. Built-in automatic controls, refrigeration, heaters and blowers.—*Hudson Bay Co., Div., Labline, Inc.*, 3070 *W. Grand Ave., Chicago* 22, *Ill.*

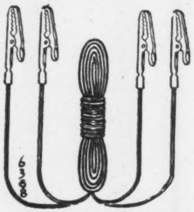


6404

For more information circle **389** on inquiry card.

ELECTRICAL TESTING

TEST LEADS



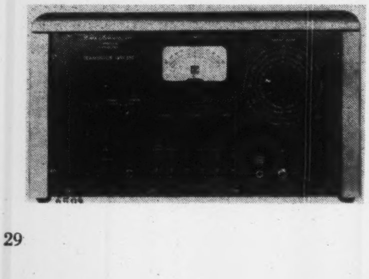
6388

New alligator-clip test leads, for hard-to-reach spots, are rubber-covered utility-type leads made of kinkless wire. Available in 12", 24", 36", and 48" lengths. — *Insuline Corp. of America*, 186 *Granite St., Manchester, N. H.*

For more information circle **390** on inquiry card.

TRANSISTOR TEST SET

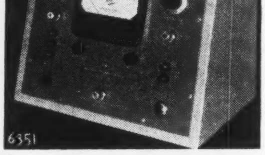
New "Model GP" provides rapid accurate measurement of transistor characteristics at any frequency from 100 cps to 1 Mc; provides measurement of *n-p-n* and *p-n-p* junction, surface-barrier and point-contact transistors in grounded-base and grounded-emitter circuits; Measurements of hybrid coefficients, T-network coefficients, collector saturation current, collector capacitance, alpha and beta cutoff, voltage feedback ratio, open circuit resistances, and channel effect voltage.—*Baird Associates, Inc.*, 33 *University Road, Cambridge* 38, *Mass.*



For more information circle **391** on inquiry card.

TRANSISTOR ALPHA TESTER

New "Model AT-10" directly indicates dynamic values of alpha and beta parameters for all types of transistors as a function of emitter an collector bias by plugging transisto into input terminals; also tests fo alpha cut-off and values of alpha a high frequencies.—*Electronic Re search Associates, Inc.*, 67 *E. Centr St., Nutley, N. J.*

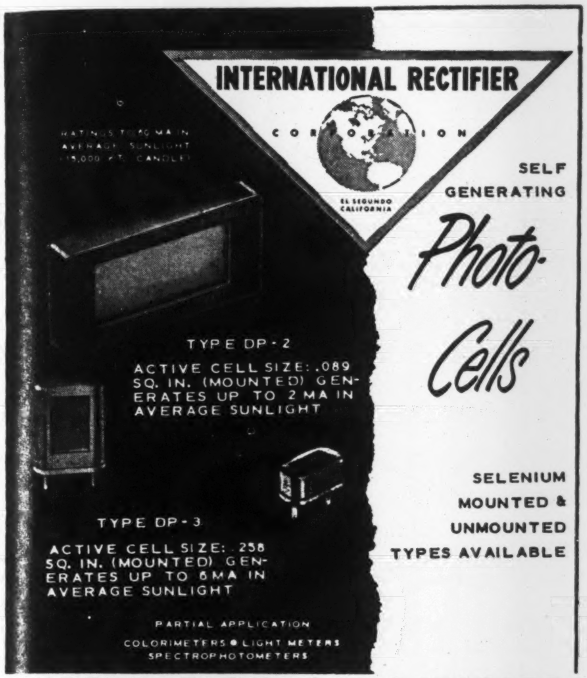


6351

For more information circle **392** on inquiry carc

ENVELOPE DELAY METER

New "Type 450-A" provides transmitted output frequency that ca be manually set, or automaticall swept repetitively through any desired portion of 200-to-10,000-cp band. Provision is also made for se



INTERNATIONAL RECTIFIER

CORPORATION

EL SEGUNDO CALIFORNIA

RATINGS TO 60 MA IN AVERAGE SUNLIGHT (15,000 FT. CANDLE)

SELF GENERATING

Photo-Cells

TYPE DP-2

ACTIVE CELL SIZE: .089 SQ. IN. (MOUNTED) GENERATES UP TO 2 MA IN AVERAGE SUNLIGHT

TYPE DP-3

ACTIVE CELL SIZE: .258 SQ. IN. (MOUNTED) GENERATES UP TO 8 MA IN AVERAGE SUNLIGHT

SELENIUM MOUNTED & UNMOUNTED TYPES AVAILABLE

PARTIAL APPLICATION

COLORIMETERS ● LIGHT METERS

SPECTROPHOTOMETERS

INTERNATIONAL RECTIFIER

CORPORATION

1521 E. Grand Ave., El Segundo, Calif • Phone: ORegon 8-6281
CHICAGO: 205 W. Wacker Drive • Phone: Franklin 2-3889
NEW YORK: 501 Madison Avenue • Phone: Plaza 5-8665

For more information circle **98** on inquiry card.

STANDARDS

ENGINEERS

for Primary Standards and Instrumentation

At Hughes we are conducting fundamental research and development and production engineering in the fields of radar systems, guided missiles, digital and analog computers, microwave tubes, semiconductor products and other activities requiring use of many types of test equipment.

Those with extensive experience in the calibration and maintenance of precision electronic and electromechanical test equipment—with emphasis on measurement of electrical quantities to very close tolerances—will find satisfying outlets for their abilities in this work at Hughes.

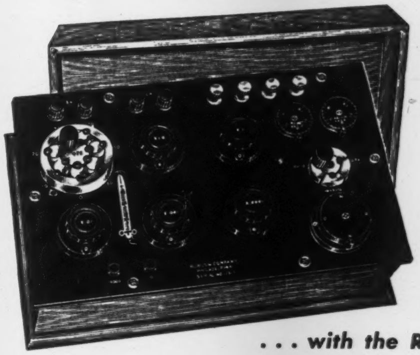
HUGHES *Scientific Staff Relations*

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Precise

TEMPERATURE MEASUREMENTS



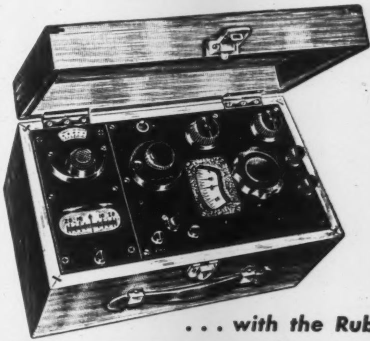
. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100



. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer—permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

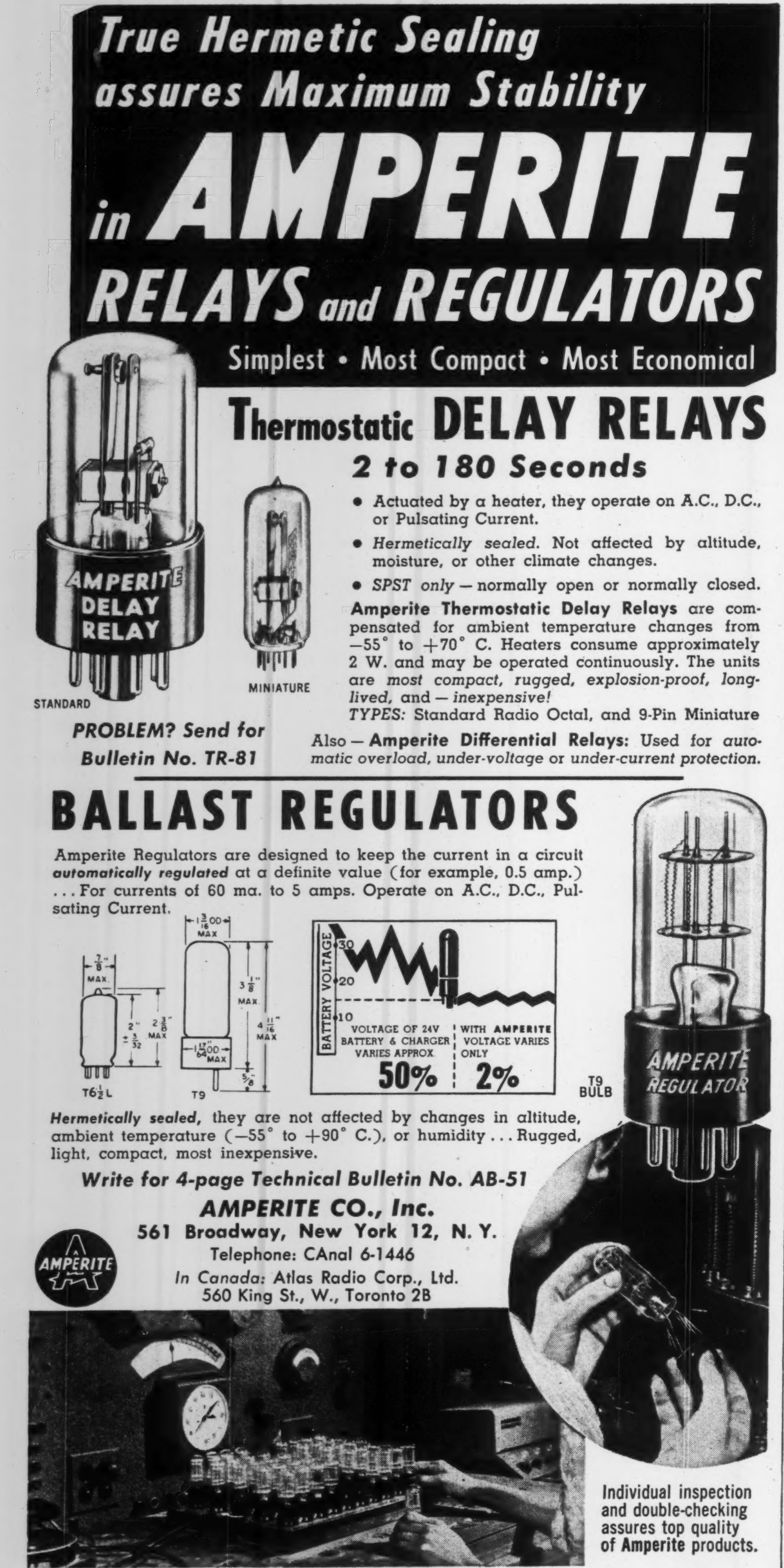
Described in Bulletin 270

RUBICON COMPANY

Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

For more information circle **99** on inquiry card.



True Hermetic Sealing assures Maximum Stability in AMPERITE RELAYS and REGULATORS

Simplest • Most Compact • Most Economical

Thermostatic DELAY RELAYS

2 to 180 Seconds

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- *SPST only* — normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from −55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

TYPES: Standard Radio Octal, and 9-Pin Miniature

AMPERITE DELAY RELAY

STANDARD

MINIATURE

PROBLEM? Send for Bulletin No. TR-81

Also — **Amperite Differential Relays:** Used for *automatic overload, under-voltage or under-current protection.*

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.) ... For currents of 60 ma. to 5 amps. Operate on A.C., D.C., Pulsating Current.

T6½L

T9

BATTERY VOLTAGE

VOLTAGE OF 24V BATTERY & CHARGER VARIES APPROX. 50%

WITH AMPERITE VOLTAGE VARIES ONLY 2%

T9 BULB

AMPERITE REGULATOR

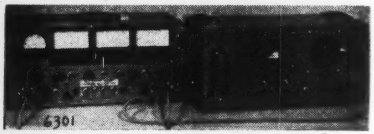
Hermetically sealed, they are not affected by changes in altitude, ambient temperature (−55° to +90° C.), or humidity ... Rugged, light, compact, most inexpensive.

Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO., Inc.
561 Broadway, New York 12, N. Y.
Telephone: CAnal 6-1446
In Canada: Atlas Radio Corp., Ltd.
560 King St., W., Toronto 2B

Individual inspection and double-checking assures top quality of Amperite products.

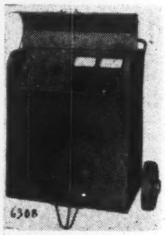
For more information circle **100** on inquiry card.



lection of automatic sweep speed: ½, 1, 2, or 4 rpm. In addition, transmitter output can be adjusted from +10 dbm to −10 dbm on a 600-ohm line. Group velocity, actual transit times, and amplitude-frequency characteristics can be determined over range of 200 to 10,000 cps. Receiver includes a frequency meter to identify frequency being transmitted and a level meter for amplitude response measurements. Receiver operating range is from +20 dbm to −30 dbm.—*Acton Laboratories, Main St., Acton, Mass.*

For more information circle **393** on inquiry card.

H-V TESTER

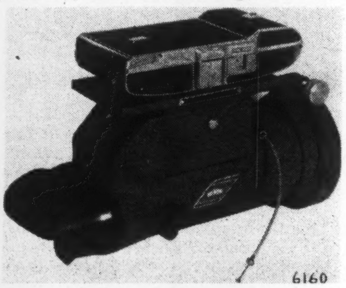


New "Model 469" is a higher-voltage addition to maker's line of mobile dc "Hypots"; has an output of 0-70 kvdc at 2.5 ma; was primarily designed for acceptance and proof testing of cables rated up to 15 kv, but is equally applicable to machinery, switchgear, etc. A 4½" voltmeter (0-70 kv) is connected directly across output; 4½" milliammeter is automatically protected against overload.—*Associated Research, Inc.,* 3766 *W. Belmont Ave., Chicago* 18, *Ill.*

For more information circle **394** on inquiry card.

C-R-O CAMERAS

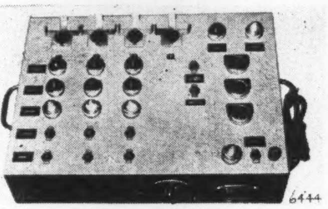
Three new oscillograph record cameras, "Types 298, 299 and 302" (shown), have interchangeable backs that permit user to employ a variet of film with a choice of three lenses can be equipped with Polaroid-Lan backs that permit permanent recordings in 60 seconds, or a Graflok-typ back that accepts a variety of Graflex film holders. In addition, backs o all three cameras can be moved to al low more than one trace to be recorded on a single frame.—*Allen B. D Mont Labs., Inc.,* 760 *Bloomfield Ave. Clifton, N. J.*



For more information circle **395** on inquiry card

ALARM-SYSTEM TESTER

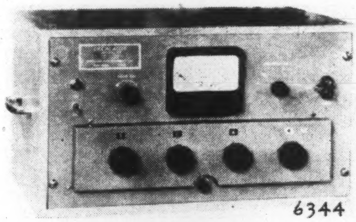
New "Panalarm Tester" checks annunciator-system plug-in relays and flashers; was developed to meet needs of users of "Panalarm" installations. —*Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.*



For more information circle **396** on inquiry card.

SIGNAL GENERATOR

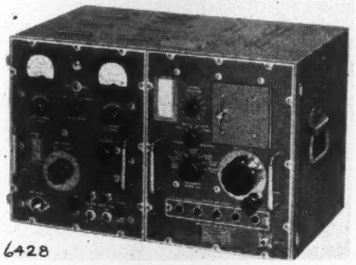
New "Decalator Model 100" is a crystal-controlled signal generator covering from 10 kc to 1.5 Mc. Features include decade switching; multiscale meter and attenuator; accuracy 100 cps; short term stability 25 cps; harmonic content 3% max; output 3 v rms.—*Decade Instrument Co., Box 153, Caldwell, N. J.*



For more information circle **397** on inquiry card.

SIGNAL GENERATOR

New "Model 269" provides seven tuning ranges; lowest is 80 kc to 2.7 Mc; highest is 96 Mc to 200 Mc. Frequency control can be obtained by means of crystals or a self-contained variable-frequency oscillator. Stability with crystal control is 0.001% and with VFO control, 0.1%.—*Munston Mfg. Co., Beech St., Islip, N. Y.*



For more information circle **398** on inquiry card.

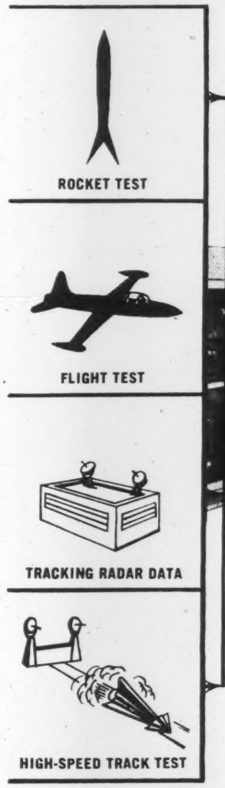
NOISE GENERATOR

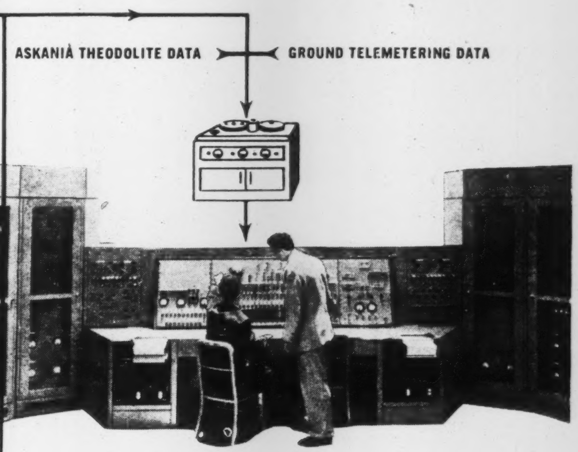
New Noise Generator measures IF amplifier and other receiver noise figures by providing a known amount of random noise to amplifier under test. This known noise can be compared to amplifier noise by using maker's Post

FOR SYSTEMS

see . . . EECO

From a single-rack recording system to a multi-console data processing center, Electronic Engineering Company has the experience and personnel to design and produce the equipment you require. EECO design techniques, perfected over years of systems work, can be put to work for you in an EECO engineered system—freeing your own engineering staff for tasks specifically related to your products.





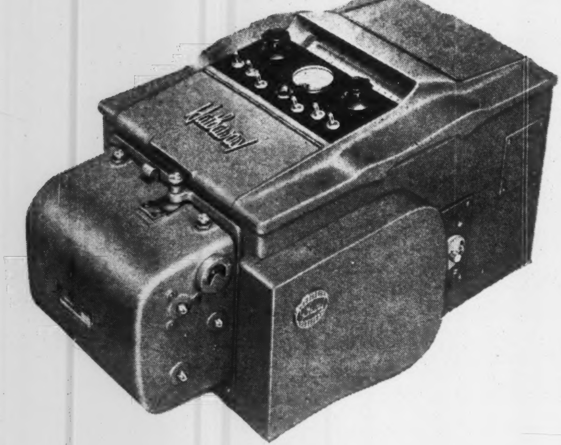
EECO Central Data Processing System, Edwards Air Force Base. System gathers data from aircraft, rocket test facilities, tracking radar, high-speed track, and processes data for analysis and/or computer input.

Plug-in Circuits
developed for EECO systems,
provide a key to lower cost
equipment design and fabrication.
Data on standard and custom
circuits available in catalog G-3.

Electronic Engineers and Physicists | Interesting and challenging work in systems and related projects offers unusual employment opportunity at EECO. Send resume to the attention of R. F. Lander.

Electronic Engineering Company
of California
and its subsidiary
EECO Production Company
180 South Alvarado Street • Los Angeles 57, California

For more information circle **101** on inquiry card.



The S14-E Oscillograph, New High in Versatility

Versatility is important in an oscillograph because it reduces instrument investment.

The Hathaway New S14-E is designed to be versatile. It can readily be used for many different types of recording and is a high quality, general-purpose oscillograph available with an unusually wide assortment of standard accessories.

The versatility and the low price of the Hathaway S14-E have established it as a "standard" instrument in many laboratories both large and small.

SPECIFICATIONS

Channels: To 24
Chart Size: 6 inches x 100 or 200 feet; 6 inches x 15 inches
Chart Speed: 1/10 to 600 inches per second
Chart Speed Change: Quick change transmission allowing 9 easily selected speeds
Galvanometers: Sensitivities to 30,000 mm per ma. per meter; frequencies to 10,000 cps; single and multi-phase watt galvanometers
Power: 115 volts, 50-60 cycles; 12 or 24 volt d-c models available on special order
Case: Walnut or lightweight aluminum
Optical System: Individually controlled galvanometer traces
Size: 24 x 13 x 14 inches
Weight: 60 pounds

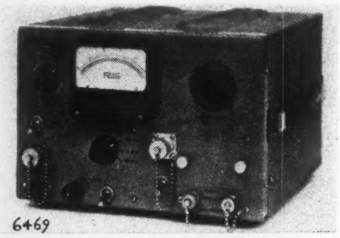
AVAILABLE ACCESSORIES

Synchronous time line markers, giving 10, 1, 1/10 and 1/100 second times lines (tenth lines heavier)
Scanning-type viewing device
Automatic recording atachments
High-speed shutter and drum for fast recording
Record numbering device

Write for Bulletin 2-D1-H

Hathaway
INSTRUMENT COMPANY
SUBSIDIARY OF
Hamilton
WATCH COMPANY
1315 SOUTH CLARKSON · DENVER, COLORADO

For more information circle **102** on inquiry card.



6469

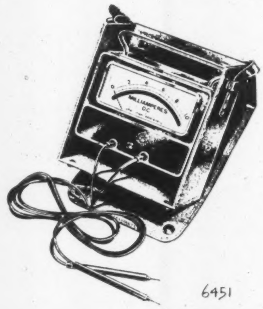
Amplifier or similar detecting device. Noise Generator features diode current indication accuracy within 1% and BNC connectors for use with single- or double-ended receiver inputs.—*RS Electronics Corp., P. O. Box 368, Station A, Palo Alto, Calif.*

For more information circle **399** on inquiry card.

ELECTRICAL INSTRUMENTS

LAB PORTABLES

New portable laboratory instruments (secondary standards) are available in 38 standard ranges with rated accuracy of either 0.5% or 1% of full-scale. Overload network provides protection up to 500 times full-scale value for short periods. Multi-range portables are also available: up to 6 ranges. All come complete with leather carrying case, calibration chart and probes.—*Phaostron Instrument and Electronic Co., 151 Pasadena Ave., South Pasadena, Calif.*

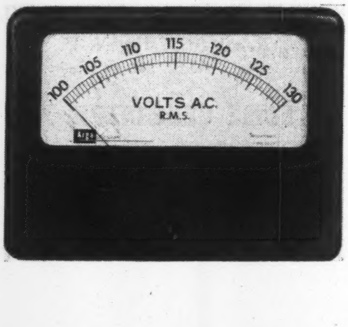


6451

For more information circle **400** on inquiry card.

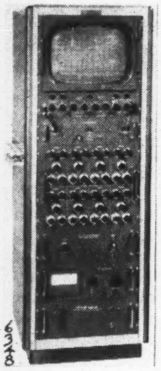
SUPPRESSED-ZERO VM's

New 115-v "Expanded Scale A-C Voltmeters" for panel mounting, available from stock, include 3½" round custom with 110-120 scale, 105-



125 scale, 100-130 scale; 3½" round military with 110-120 scale, 110-130 scale; 3½" square custom with 100-130 scale; 4½" round military with 100-130 scale; 4" x 6" rectangular custom with 100-130 scale.—*Arga Div., Beckman Instruments, Inc.*, 220 *Pasadena Ave., So. Pasadena, Calif.*
For more information circle **401** on inquiry card.

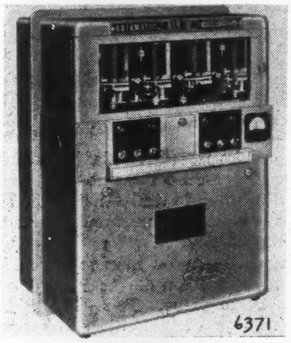
8-CHANNEL OSCILLOSCOPE



New "Dynamic Strain Gage Indicator" features continuous display of eight independent channels of strain-gage output information plus calibration data for each channel; is said to be "the only device of its kind in the instrumentation field." Below 17" crt display unit are mounted a control panel, gage balance and calibration panel containing 8 independent channels, a sequential switching panel, and a gage excitation power supply. All 8 channels are scanned each ½-second. —*Electromec, Inc.*, 5121 *San Fernando Road, Los Angeles* 39, *Calif.*
For more information circle **402** on inquiry card.

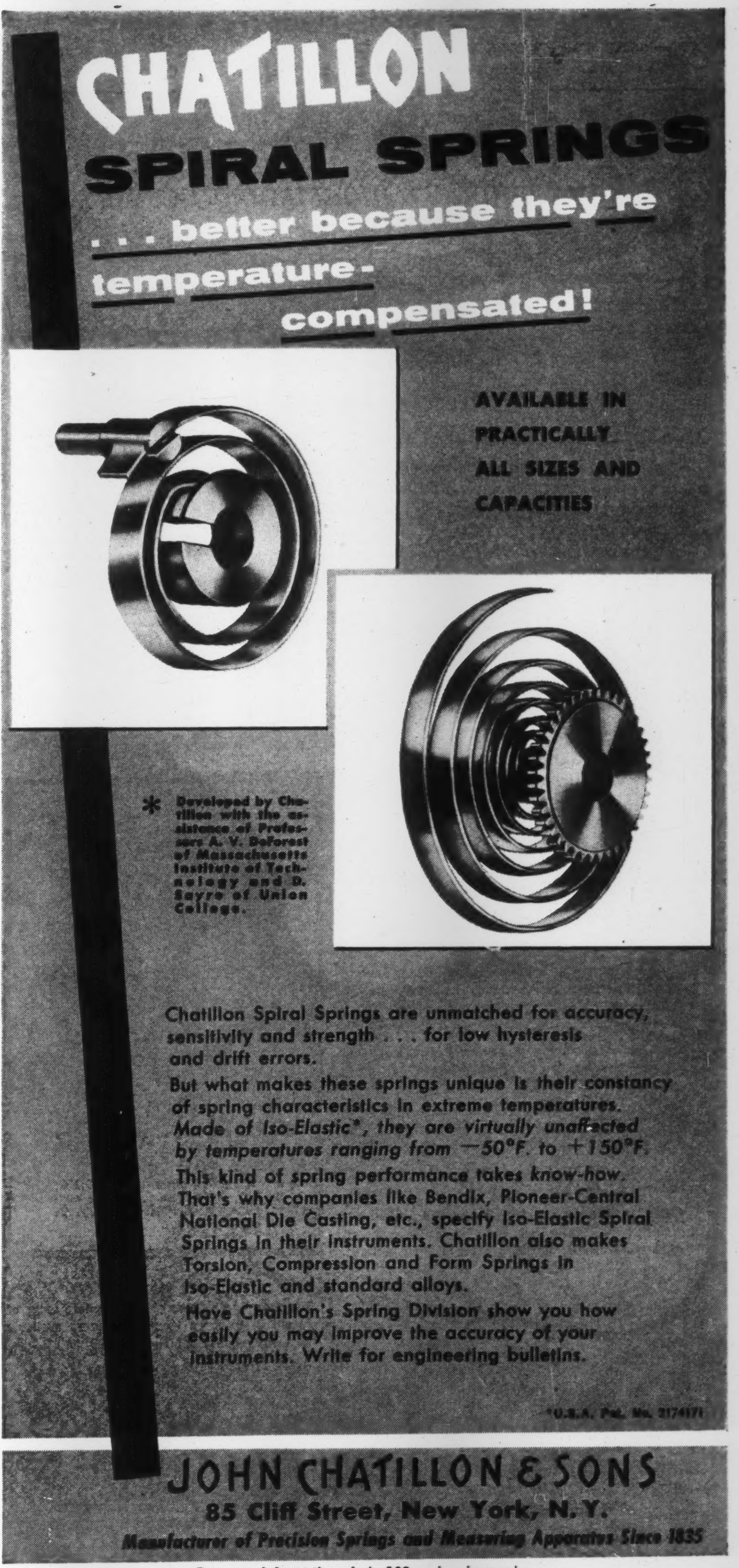
30-CHANNEL OSCILLOGRAPH

New "RS9-Thirty" automatic oscillograph starts to record automatically when a fault occurs, and reaches full recording speed in 2 milliseconds. Starting relays are available to initiate oscillograph from any selected fault condition. Chart speeds 12 ips and 3 ips; either is selected by starting relays. Sensitized paper chart 12" wide is loaded in 200-ft or 300-ft rolls; supply and take-up spools housed in light-tight cartridges.—*Hathaway Instrument Co.*, 1315 *S. Clarkson St., Denver* 10, *Colo.*
For more information circle **403** on inquiry card.



AF WAVE ANALYZER

New "Type FT-FNA" separates a complex waveform in audiofrequency range into its spectral components; is completely self-contained: includes analyzer, two-axis recorder, filter and


CHATILLON
SPIRAL SPRINGS
. . . better because they're temperature-compensated!

AVAILABLE IN PRACTICALLY ALL SIZES AND CAPACITIES

* Developed by Chatillon with the assistance of Professors A. V. DeForest of Massachusetts Institute of Technology and D. Sayre of Union College.

Chatillon Spiral Springs are unmatched for accuracy, sensitivity and strength . . . for low hysteresis and drift errors.

But what makes these springs unique is their constancy of spring characteristics in extreme temperatures. *Made of Iso-Elastic*, they are virtually unaffected by temperatures ranging from —50°F. to +150°F.*

This kind of spring performance takes know-how. That's why companies like Bendix, Pioneer-Central National Die Casting, etc., specify Iso-Elastic Spiral Springs in their instruments. Chatillon also makes Torsion, Compression and Form Springs in Iso-Elastic and standard alloys.

Have Chatillon's Spring Division show you how easily you may improve the accuracy of your instruments. Write for engineering bulletins.

*U.S.A. Pat. No. 2174171

JOHN CHATILLON & SONS
85 Cliff Street, New York, N.Y.
Manufacturer of Precision Springs and Measuring Apparatus Since 1835

For more information circle **103** on inquiry card.

OXYGEN

key to modern industrial processes

Control it with ...

Arnold O. Beckman

OXYGEN ANALYZERS!

Oxygen in some form or other is one of the most important factors found in modern chemical and industrial processes. Whether to minimize product oxidation (prepared atmospheres, air infiltration, etc.) ... or to insure adequate oxygen for efficient combustion (boilers, kilns, etc.) ... or to control oxygen for proper process operations (ammonia, acetylene, air fractionation, etc.) oxygen control has become too important in today's operations for any profit-minded executive to ignore.

And because they are the *only* instruments that measure oxygen content directly, accurately and conveniently, Arnold O. Beckman Oxygen Analyzers have become the leading instruments for modern oxygen control in a wide range of applications—from catalytic refineries to cement kilns—from power plants to personnel protection.

These instruments (and systems) can be built to meet *your individual* needs.

These instruments offer many unique advantages ...

SELECTIVITY: Highly sensitive to oxygen. Effects of gases other than oxygen are negligible.

HIGH ACCURACY: 1% of full scale (Example: ±0.05% O_2 on range 0-5% O_2).

MANY RANGES: Full scale ranges from 0-1000 ppm or up to 0-100% O_2 available. Combustion ranges 0-5, 0-10, 0-15% O_2 supplied with 0-25% O_2 check range. Multi-range instruments available.

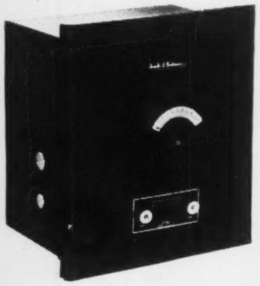
RAPID RESPONSE: Standard Analyzers—95% response in less than 1 minute. Special Units—95% response in 7 **seconds!**

USE ANY RECORDER: Millivolt output for potentiometers; current output for miniature electronic recorders and galvonometers; air output for pneumatic receivers and control systems.

PACKAGE UNITS: Analyzers and controls may be built into a cubicle with sampling components wired, piped, and ready for installation as a single unit.

SAMPLING SYSTEMS: Complete standard systems—components, package or portable units are available.

OTHER ADVANTAGES: Instruments may be mounted in explosion-proof cases, mounted indoors or outdoors, in portable panels, and have other desired features.



Model F3: Ranges of 0-1%, 0-5%, 0-10%, and higher. Meter on door for convenient readings at sampling point.

Model G2: Full scale ranges 0-0.1%, 0-0.5%, and others for low O_2 content. Ranges 90-100%, 95-100% O_2 for high O_2 content.

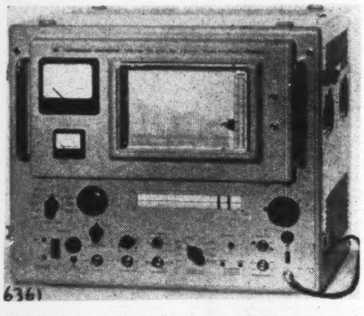
The above are but two of the complete range of Arnold O. Beckman Oxygen Analyzers available for every requirement.

Send for helpful free literature which describes Arnold O. Beckman instruments in detail. When writing, outline your particular application—we'll gladly supply specific information.

Ask For Data File 20G-36

Arnold O. Beckman INC.
ANALYZERS
Profit Builders for Industry
1020 Mission Street
South Pasadena, California

For more information circle **104** on inquiry card.



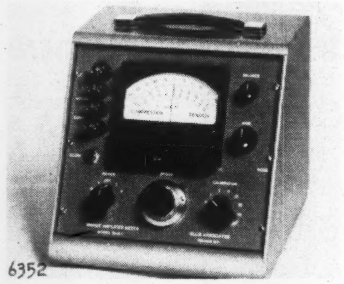
6361

other apparatus for complete manual or automatic frequency analysis; features extraordinary selectivity with switch-over facility for narrow (10 cps) and wide (200 cps) bandwidth operation; logarithmic or linear response; sensitivity of measurement: as low as 1 uv.—*Instrument Div., Federal Telephone and Radio Co., 100 Kingsland Road, Clifton, N. J.*

For more information circle **404** on inquiry card.

DC AMPLIFIER-INDICATOR

New "BAM-1 Bridge Amplifier and Meter" is suitable for both static and dynamic measurements with resistive-type pickups. For static measurements, zero-center scale reads compression on left and tension on right. For dynamic measurements, a dc CRO is plugged in and gives "a beautiful dc signal with no microphonics." Response flat from dc to 25,000 cps.—*Ellis Associates, Box 77, Pelham, N. Y.*

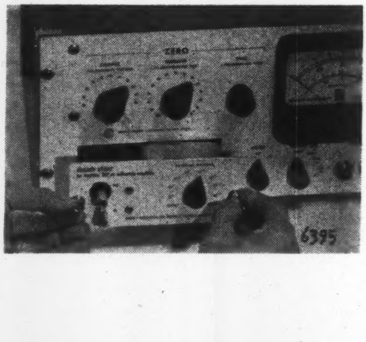


6352

For more information circle **405** on inquiry card.

DC AMPLIFIER-INDICATOR

New "Model 303 DC Indicating Amplifier" has an input impedance of over one million megohms, a maximum gain of 160,000, and a frequency



6395

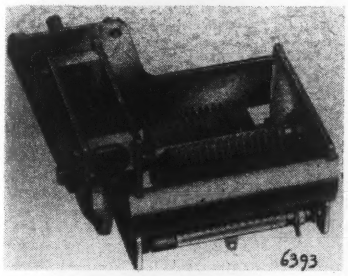
response of dc to 100 kc. Indicator's range is 2 to 2000 mv but plug-in multipliers extend it to 800 v. Among other features: power amplifier for driving all common direct-writing recorders; zero drift less than 2 mv per hour; plug-in decade shunt that converts instrument to micromicroammeter.—*Keithley Instruments, Inc.,* 3868 *Carnegie Ave., Cleveland* 15, *Ohio.*

For more information circle **406** on inquiry card.

ELECTR-INSTRUMENT ACCESSORIES

HIGH-PRECISION CAPACITOR

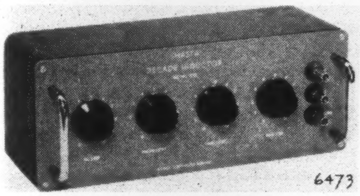
New "Model #2070" capacitor is a precision 100-to-1 worm-drive unit whose rotors and stators are insulated with new high-strength pink or blue alumina ceramic rods so held as to be under spring tension: highly resistant to shock, yet extremely stable. Nickel-steel alloys are used for frame, rotor and stator, whence a temperature coefficient of practically zero. Because of proper design of worm-drive and bearings, unit can be reset to 0.002%. Capacitance variation from 15 to 150 mmf.—*Johanson Mfg. Corp., Boonton, N. J.*



For more information circle **407** on inquiry card.

DECADE INDUCTOR

New "Model 1210" provides inductance values in range from 0.001 henry to 11.11 henries in 0.001-h steps. Accuracy 1%; toroidal construction minimizing effects of external magnetic fields and permitting close stacking of coils without errors from mutual inductance.—*Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A Richmond, Calif.*



For more information circle **408** on inquiry card.

"ANALOG" FILTER

New "Model LH-24 Analog Filter" is a direct-coupled variable electronic filter with cut-off frequency tunable from 0.2 to 20,000 cps, which can be

BROOKS LEADERSHIP *achieved by design*

dowel-pins are the difference

NO TORQUE
NO LINE STRAIN

8 stainless steel dowel-pins precisely align the side plates and end fittings, are the keys to quick, trouble-free assembly and maintenance of the Brooks Full-View* Rotameter. The metering tube is installed after the frame is completely assembled. Tube breakage due to line strain and misalignment is thereby eliminated. It's as simple as placing a round peg in a round hole.

This feature, if considered alone, would make *dowel-pin, side-plate* construction your most important rotameter specification.

Send for Bulletin 115

*Trade-Name

TM

a complete line... **BROOKS**
ROTAMETERS *...for every service*

BROOKS ROTAMETER COMPANY
104 EIGHTH STREET • LANSDALE, PA.

For more information circle **105** on inquiry card.

HEISE GAUGES

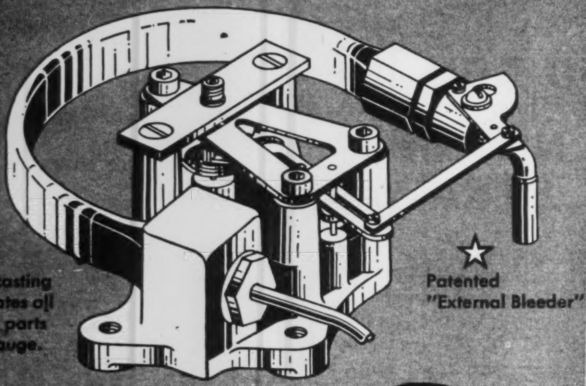
★ Permanent positive accuracy of alignment guaranteed by integral construction.

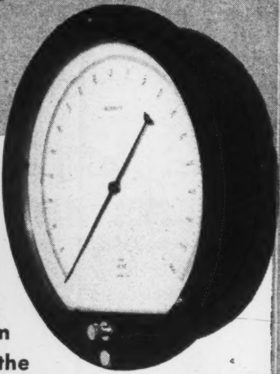
Weldless heat treated Bourdon tube maintains precise calibration. ★

★ Massive Bronze casting coordinates all working parts of the gauge.

★ Patented "External Bleeder"

★ Dial individually engraved with reference to the pressure gradient of its gauge mechanism.





ACCURACY

The standard of excellence maintained by Heise qualifies this instrument for the most exacting requirements. Designed to maintain permanently its inherent precision, the Heise gauge is often used in place of the dead weight tester in checking other instruments. Consistently accurate performance as a calibration reference has established its recognition as THE STANDARD OF THE WORLD.

SPECIALIZATION AND EFFICIENCY

Heise Laboratories have always specialized in the design and production of high precision pressure gauges. The highest standards of quality control protect the manufacture and assembly of each component and the permanent calibration of the finished instrument.

Efficiency in the production of one type instrument, precision pressure gauges, has made it possible to maintain a prompt delivery schedule.

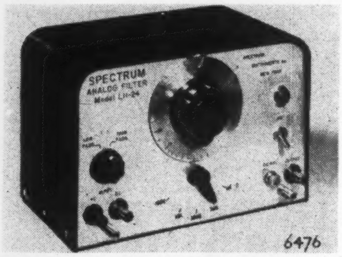
DELIVERY WITHIN 30 DAYS.

Pressure Range 15 to 20,000 P.S.I.
Dial Sizes 8½"—12"—16"
Prices from $151.60

Catalog on Request

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle 106 on inquiry card.

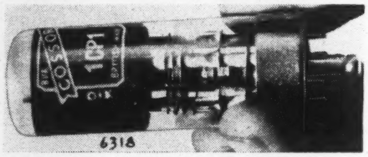


used as either high-pass or low-pass filter by means of a panel mode-selector switch. As a low-pass filter it is unusual in offering cut-off values useful in sonic and subsonic frequency work in combination with a direct-coupled circuit which permits true low-pass performance to zero frequency. Designation "Analog Filter" stems from mathematical equivalence of input-output voltage-frequency characteristic to that of a properly-terminated inductance-capacitance filter.—*Spectrum Instruments, Inc.*, 44-05 30*th Ave.*, *Long Island City*, *N. Y.*

For more information circle **409** on inquiry card.

SELF-FOCUSING CRT

New "Cossor 1CP1" flat-face 1" cathode-ray tube, said to be ideal for monitoring purposes in a wide variety of electronic circuits, features (1) automatic self-focusing at low anode voltage from 500 to 1500 v and 250-v heater-cathode insulation, permitting wide choice of heater power sources; (2) newly-designed electrodes and structure utilizing precision ceramic tubular spacers exclusively, and new screen material said to provide longer life for continuous operation.—*Beam Instruments Corp.*, 350 *Fifth Avenue*, *New York* 1, *N. Y.*

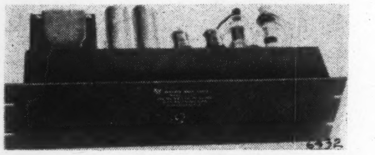


For more information circle **410** on inquiry card.

POWER SUPPLIES, AMPLIFIERS, etc.

PHOTOMULTIPLIER SUPPLY

New "Model CS-324" high-stability photomultiplier power supply is available in basic chassis form for incorporation in optical devices, or in rack-panel cabinet form for laboratory use. It provides better than 0.1% line and



load regulation; long-term stability better than required for most applications; ripple less than 1 part in 50,000. Output voltage can be any 200-v range from 1000 to 2000 vdc; output current rating 5 ma.—*NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.*

For more information circle **411** on inquiry card.

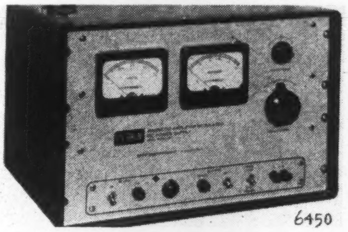
HV POWER SUPPLY

New "Model 75BR" high-voltage power supply, announced as "high voltage in a small package, at very low cost," is complete and self-contained in a cabinet 7¼"H x 8"W x 8"D, with a 3" voltmeter as standard equipment. Voltage range 2 to 7.5 kvdc; current 1 ma @ 6 kv; regulation better than 1%.—*Neutronic Associates, 87-16 116th St., Richmond Hill 18, N. Y.*

For more information circle **412** on inquiry card.

MAG-AMP-REG DC SUPPLY

New "Model MR 532-15A" is a magnetic amplifier regulated power supply said to be "very unique in that it has a voltage range available between 2 and 36 volts and between 5 and 32 volts."—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*



For more information circle **413** on inquiry card.

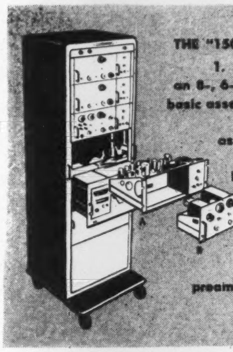
LINE VOLTAGE REGULATOR

New "Model MA 1000 S" tubeless ac line voltage regulator has output load range of 0 to 1000 va; uses a magnetic-amplifier-controller circuit with a silicone diode reference element; is basically insensitive to frequency variations; is particularly applicable to unattended installations; features wide input frequency range 55 to 65 cps. Regulation accuracy is 0.5% against line or load. Available as a rack- or cabinet-mounted unit.—*Sorenson and Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

For more information circle **414** on inquiry card.

DC POWER SUPPLIES

New "Stablvolt Type A Series" precision-regulated dc power supplies in 200- and 1000-watt outputs employ



THE "150" DESIGN CONCEPT

1. A system starts with an 8-, 6-, 4-, 2- or 1-channel basic assembly which includes a complete recorder assembly, and a Driver Amplifier and Power Supply (A) for each channel.

2. To this basic assembly are added interchangeable plug-in type preamplifiers (B) according to the measurement requirements.

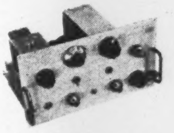
HERE'S REAL oscillographic RECORDING VERSATILITY

DEMONSTRATED AT BOOTHS 455 AND 457 ELECTRONICS AVENUE I. R. E. SHOW

A Sanborn "150 Series" System can be set up to record any of these inputs in any of the channels.

AC or DC Signals,

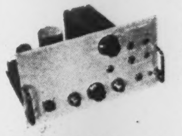
balanced or single-ended, with sensitivity of 1 mv to 2 v/cm (AC), 1 mv to 2 v/mm (DC).



AC-DC Preamp

Low Level Signals,

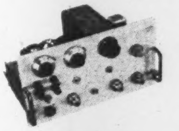
with extreme stability, high gain, and greater bandwidth than with 150-1500 Low Level Preamplifier.



STABILIZED DC Preamp

Magnitude and Direction of Physical Variables,

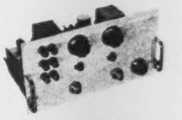
with variable resistance, differential transformer or variable reluctance transducers.



CARRIER Preamp

Average Value of AC Watts in a Circuit,

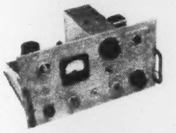
in ranges from 25 volts x 40 ma to 250 volts x 2 amps. (with internal multipliers and shunts which can handle up to 4 amps).



AC WATTMETER Preamp

AC Voltage Components

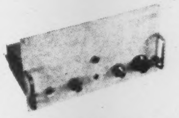
in phase or 180° out of phase with a reference voltage (e.g., servo error signal).



SERVO MONITOR Preamp

Higher Level Signals

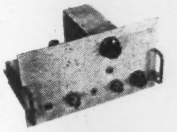
where maximum sensitivity of 1 v/cm, and input impedance of about 200,000 ohms are adequate.



INPUT COUPLING NETWORK

DC Signals

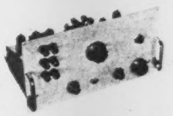
(push-pull, single-ended or difference between two). Basic sensitivity 50 mv/cm to 50 v/cm.



DC COUPLING Preamp

RMS Values of AC Voltages, Currents,

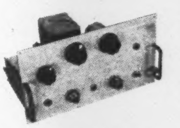
from 25-250 volts, 50 ma — 1 amp.



VOLT/AMMETER Preamp

Logarithmic Level Signals,

Audio signals (20 cycles to 20 KC) or DC voltages recorded in logarithmic fashion on 50 decibel chart.



LOG-AUDIO Preamp

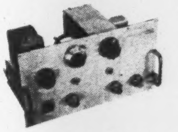
Symmetric or Asymmetric Waveform Inputs,

in 350-450 cycles (2 cycles/mm) and 375-425 cycles (1 cycle/mm) ranges.

FREQUENCY DEVIATION Preamp

Extremely Low Voltages and Currents,

at sensitivities of 100 μv and 1 μa per cm. (with external shunt of 100 cycles), by means of DC chopper circuit.



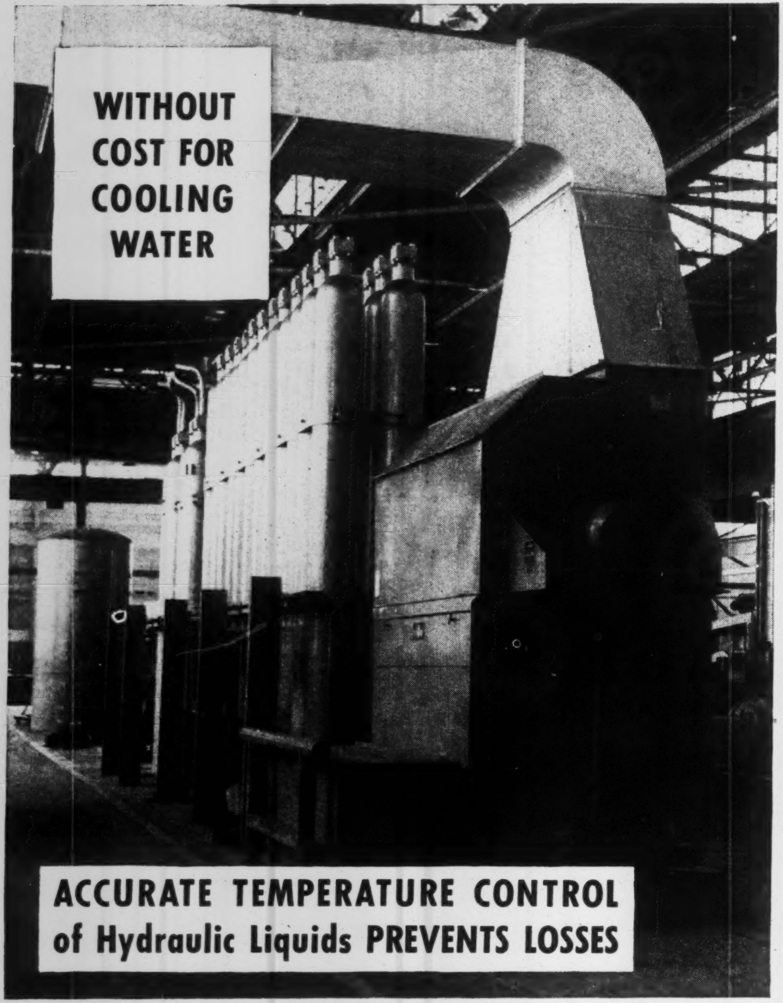
LOW LEVEL Preamp

BASIC "150" design features include: inkless recording in true rectangular coordinates, improved overall linearity, numerous paper travel speeds, and a choice of mobile-cabinet or portable-case packaging in 2-, 4-, 6-, and 8-channel systems.

Sanborn Representatives will be glad to help you select the equipment best suited to your needs. Complete catalog available.

SANBORN COMPANY, Cambridge 39, Mass.

For more information circle **107** on inquiry card.


WITHOUT COST FOR COOLING WATER
ACCURATE TEMPERATURE CONTROL of Hydraulic Liquids PREVENTS LOSSES

● This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

Air is free and cheaper to move than water. You can save much expense in pumping, piping and power, and quickly recover the equipment cost from the water saving.

Similar Niagara machines cool water, oils, solutions, lubricants and coolants for many mechanical, electrical and chemical processes. You can cool quench baths, welding machines, plastic molds, furnaces, controlled atmospheres, gases, compressed air either for power or instruments or processes. In a closed system, your coolant is never contaminated. The system is simple and easy to keep up; the equipment has a long, useful life. Select from a wide range of sizes up to 30,000,000 BTU.

Write for Bulletin 120 to obtain a complete description.

NIAGARA BLOWER COMPANY

Dept. IN, 405 Lexington Ave. New York 17, N. Y.

Niagara District Engineers in Principal Cities of United States and Canada

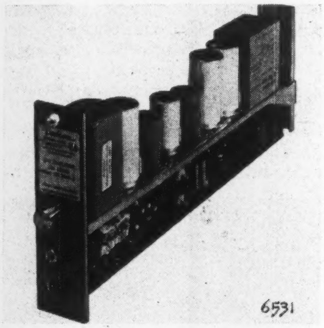
For more information circle **108** on inquiry card.

hermetically-sealed long-life magnetic amplifiers instead of tubes. "Ultra high speed response" and regulation of 0.2% for line and load over entire dc output range are obtained through use of new high-performance flux oscillators in connection with high-gain magnetic amplifiers.—*Magnetic Research Corp.*, 202 *Center St., El Segundo, Calif.*

For more information circle **415** on inquiry card.

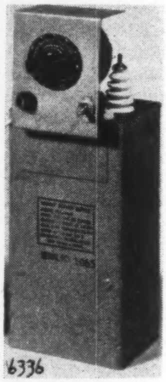
WIDE-BAND D-C AMPLIFIER

New "Model C23125 Wide Band D-C Amplifier, Plug-In Type" is specifically designed to serve as a low-level preamplifier in data-handling systems where millivolt signals must be amplified with a high degree of linearity, stability and speed of response. Unique feature: use of maker's "Second-Harmonic Magnetic Converter" as input stage, eliminating mechanical-type chopper and completely isolating input from amplifier chassis and circuit ground.—*Doelcam Div., Minneapolis-Honeywell,* 1400 *Soldiers Field Road, Boston* 35, *Mass.*


6531

For more information circle **416** on inquiry card.

VARIABLE TRANSFORMER


6336

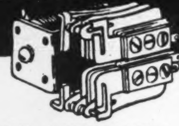
New "Model 15-IM 60" variable output power supply incorporates a new variable transformer which controls input and output voltages, is spot welded to power supply and obviates need for a separate variable input transformer for this purpose. Control dial is calibrated in percentages of line voltage, rather than in voltage.—*Condenser Products Co.*, 140 *Hamilton St., New Haven, Conn.*

For more information circle **417** on inquiry card.

PEN RECORDER AMPLIFIER

New dc amplifier meets exacting requirements of lab and portable recorders; features adjustable gain to

RELAYS



MINIATURE AIRCRAFT
TELEPHONE TYPE
HERMETICALLY SEALED
SENSITROLS
STEPPING SWITCHES
GUARDIAN • KURMAN
ALLIED • SIGMA • LEACH
and many others

LARGEST STOCK OF RELAYS IN THE WORLD

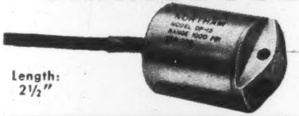
PRODUCTION QUANTITIES IN STOCK

Send for our latest bulletin– I

324 CANAL ST., N.Y.C., 13, N.Y. WAlker 5-9642
Universal general corp.

For more information circle **109** on inquiry card.

NORTHAM
DIFFERENTIAL PRESSURE TRANSDUCER



Length: 2½"

Weight: 12 oz.

A variable inductance instrument for measurement of differential pressures in ranges ± 200 to ± 5,000 psi and line pressures up to 5,000 psi. Designed for rocket and jet engine testing involving extreme mechanical disturbances, and for general laboratory measurement and industrial control applications.

MODEL DP-15 SPECIFICATIONS:

Pressure Ranges: . . ± 200 to ± 5,000 psid
Maximum Line Pressure: . . . . 5,000 psi
Accuracy: . . . . ± 1% full scale
Excitation Frequency: From 60 to 20,000 cps
Natural Frequency: From 2,000 cps to 10,000 cps depending on range
Acceleration Response: Less than 1%/1,000 g along most sensitive axis (range above 1,000 psi) Less than 1%/1,000 g axial (all ranges)

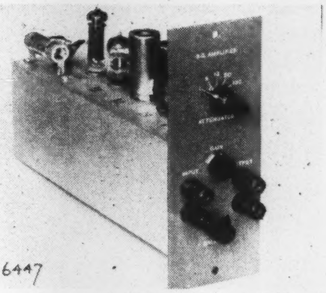
WRITE FOR BULLETIN NO. IA-15

Northam Engineering Facilities Are Available To Assist You With Any Application Problems.

NORTHAM PRODUCTS INCLUDE . . .
Transducers for pressure, acceleration and displacement measurement and auxiliary electronic equipment for complete systems.

NORTH AMERICAN INSTRUMENTS, INC.
2420 North Lake Avenue • Altadena, Calif.

For more information circle **110** on inquiry card.

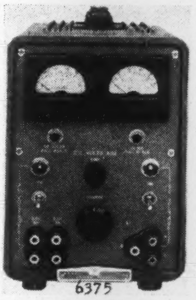


6447

a maximum of 400 with low drift; no oscillations regardless of gain balance or compensator setting; compensation for response characteristics of recorder used.—*Ralph M. Parsons Co., 135 W. Dayton St., Pasadena, Calif.*

For more information circle **418** on inquiry card.

MULTI-PURPOSE SUPPLY

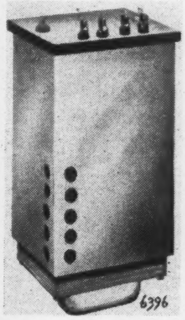


6375

New "Model 711A," designed to power all types of lab, field and factory electrical test setups, delivers 0 to 500 vdc; features no-load to full-load regulation better than 0.25% or 0.5 v; ripple less than 1 mv; push-button range switching for measurement of small voltages and currents; complete overload protection, and grounding of + or — dc terminals.—*Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.*

For more information circle **419** on inquiry card.

V-R SUPPLIES



6396

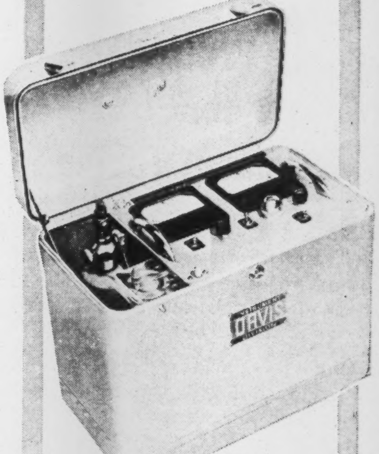
New voltage-regulated power supplies are especially designed for operation of radio tube filaments used in electronic equipment and experimental devices. Their voltage output varies inversely with tube filament load so that filaments varying by 10% in resistance receive same wattage. Five available models meet most requirements; special units for either ac or dc output can be supplied with regulation to 0.1%.—*Kemlite Labs., 1813 North Ashland Ave., Chicago 22, Ill.*

For more information circle **420** on inquiry card.

V-R SUPPLIES

New "1.5 Ampere KR Series Power Supplies" feature one regulated B supply and two unregulated filament outputs. Four models deliver 0-150, 100-200, 195-325, and 295-450 vdc

Measures oxygen and combustibles simultaneously!



DAVIS PORTABLE COMBUSTION TESTER

A double duty portable precision instrument for the analysis of exhaust gases in varied combustion processes. Oxygen and combustibles measured and indicated on separate meters simultaneously. A Davis representative will gladly arrange a demonstration at your plant.

Size: 18" x 12" x 18"
Weight: 40 lbs.
115V, 60 cycle operation

Send for Bulletin 11-34

INSTRUMENT DAVIS DIVISION

DAVIS INSTRUMENTS
Division of
Davis Emergency Equipment Co., Inc.
80 Halleck Street, Newark 4, N. J.

For more information circle **111** on inquiry card.

INSTROF

Continuous Support
and Protection
for
Instrument Tubing

Tubing may readily be run to individual instruments or panels as needed.

Delicate instruments quickly become useless without adequate tubing support. Instrof provides a flexible, simple-to-install system for maximum efficiency and dependability at minimum cost. Famous Pin-Type Coupling available for wide range of standard fittings and runs.

Instrof is a system of Prefabricated Expanded Metal Trough specifically designed for rigid, continuous support and protection of instrument tubing. All parts are hot-dip galvanized for long life. Widths of 3'', 6'', 9'', 12'', 18'', and 24'', lengths of ~~8'~~, 10', and 12', and a complete line of fittings allow the Instrof system to meet the demands of virtually any plant layout.

Exclusive Pin-Type Coupling speeds installation and reduces labor costs. Just two coupler pins and a bottom plate are needed to complete a connection.

INSTROF CORP.
DIVISION T. J. COPE, INC.
711 SOUTH FIFTIETH STREET
PHILADELPHIA 43, PENNA.

Straight Reducer
Vertical Tee
90° Riser Elbow (Inside)

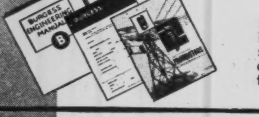
For more information circle **112** on inquiry card.

IT SAYS THAT 2 OUT OF 3 ELECTRONIC ENGINEERS USE BURGESS BATTERIES

BURGESS
BURGESS

BURGESS DESIGN AND ENGINEERING SERVICES CAN SOLVE YOUR PROBLEM!

For more than forty years, Burgess has offered to Electronic Engineers design and engineering facilities to meet any dry battery need. Burgess welcomes the opportunity to assist in solving your problems. Burgess popularity is based on uniform performance and consistent high quality that have earned and held the respect of Engineers everywhere. Your local distributor carries a complete stock of Burgess Industrial Batteries.

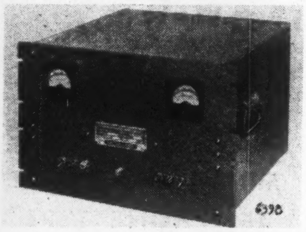


FOR YOUR CONVENIENCE!

Burgess offers, at no charge, an engineering manual listing the complete line of Burgess Batteries, a handy check sheet for new battery specifications and the new Transistor catalog folder. Ask your distributor or write Burgess Battery Company for your free copies today.

BURGESS BATTERIES
BURGESS BATTERY COMPANY
FREEPORT, ILLINOIS

For more information circle **113** on inquiry card.



respectively; regulation better than 0.2 v for line fluctuations from 105 to 125 v or load variation from 0 to 1.5 amp; ripple less than 3 mv. Each of the two unregulated filament outputs delivers 6.3 v, 15 amps.—*Kepco Labs.*, 131-38 *Sanford Ave., Flushing* 55, *N. Y.*

For more information circle **421** on inquiry card.

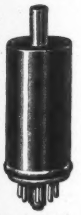
ELECTRICAL COMPONENTS

PLUG-IN FLIP-FLOP

New "Universal Flip-Flop Encapsor AL-B-329" is a low-speed Eccles-Jordan bistable multivibrator circuit designed to operate from 0 to 100 kc under various input and load conditions, with provisions made to obtain output from both plates, to reset, to apply triggering to either grid or to both grids simultaneously, and to apply feedback to either stage of flip-flop. One "AL-B-329" can be directly connected to drive a succeeding "AL-B-329" unit. Among applications: ring, decade or linear counting, sequential switching or scanning, step-function generating, frequency dividing and matrix switching.—*Alcor Electronics Corp.*, 180 *Lafayette St., New York* 13, *N. Y.*

For more information circle **422** on inquiry card.

HIGH-VOLTAGE CONVERTER



New high-voltage converter changes battery voltage directly to high voltage; plugs in like a radio tube. Input 3 vac or dc; output variable from zero to 6,000 vac (or dc when rectified). Current of 1 ma available when set to 130 vdc. For miniature power supplies, ignition, infrared devices, Geiger counters, etc.—*Precise Measurements Co.*, 942 *Kings Highway, Brooklyn* 23, *N. Y.*

For more information circle **423** on inquiry card.

VOLTAGE REGULATOR TUBES

New "Types 6626 and 6627" (replacing "OA2 and OB2)" are said to be "highly versatile gaseous voltage regulator tubes featuring greatly improved reliability, improved dark starting, and elimination of voltage shifts." They are recommended in such critical applications as voltage reference circuits where extreme stability

and repeatability are vital factors.—*CBS-Hytron, Div. of Columbia Broadcasting System, Inc., Danvers, Mass.*
For more information circle **424** on inquiry card.

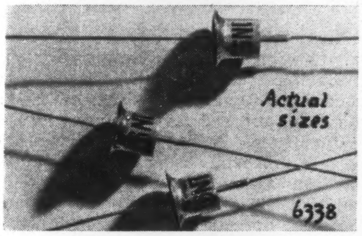
POWER TRANSISTOR

New "Type 970" silicon power transistor is of grown-junction *n-p-n* type with layers of different conductivity silicon produced in the large parent single crystal as it is "grown" in maker's equipment. Power dissipation is 8.75 watts maximum at 25°C; 3.5 watts maximum at 100°C. Power gain at 100°C ranges from a guaranteed 28 db at 1-watt output, Class A operation, to a guaranteed 18 db at 2.5 watts output, Class B operation.—*Texas Instruments Inc.,* 6000 *Lemmon Ave., Dallas* 9, *Texas.*
For more information circle **425** on inquiry card.

Actual size
6482

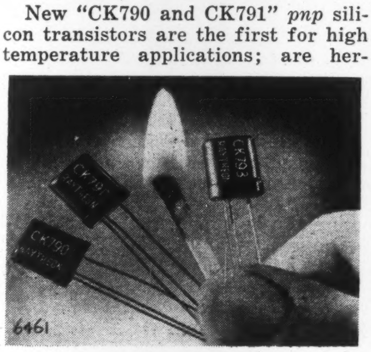
POWER DIODES

New "Types 1N91, 1N92 and 1N93" germanium junction power diodes are designed for use in high-level modulation and detection in communications and control, AF switching and rectification in power range up to 25 watts; are said to achieve "characteristics never before possible in either thermionic or in other types of solid-state rectifiers." They combine low forward resistance with high back resistance so that 100% rectification efficiency is approached.—*Clevite Transistor Products,* 241-257 *Crescent St., Waltham* 54, *Mass.*
For more information circle **426** on inquiry card.



PNP SILICON TRANSISTORS

New "CK790 and CK791" *pnp* silicon transistors are the first for high temperature applications; are her-



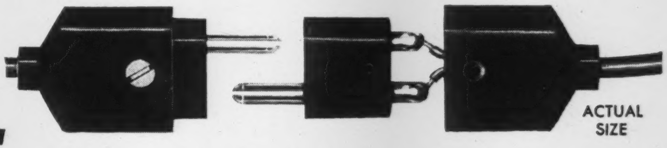
NEW Miniature Lightweight Thermocouple Connector

1-2-3 Ways NEW...

ALL-WAYS BETTER

Unique, ultra-versatile design is adaptable to virtually all of your temperature measuring applications. Saves you time and money. Same ingenious jack design is used in all three models. Available in Iron Constantan, Copper-Constantan, and Chromel Alumel. Other Combinations of metals are available on special order.

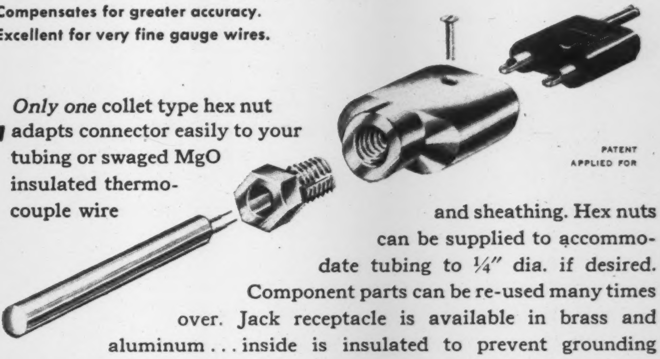
1-



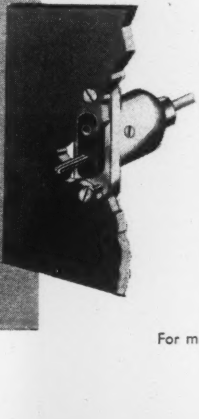
Connect or disconnect in a matter of seconds . . . only two screws in complete unit . . . small screwdriver, pencil soldering iron and solder are the only tools used to attach wires.

- **Polarized . . . color coded . . . identified + and — . . . Eliminates errors in polarization.**
- **Positive lock can be supplied for use where vibration is a factor.**
- **Phenolic material withstands approximately 500°F.**
- **Compensates for greater accuracy.**
- **Excellent for very fine gauge wires.**

2- *Only one* collet type hex nut adapts connector easily to your tubing or swaged MgO insulated thermocouple wire and sheathing. Hex nuts can be supplied to accommodate tubing to ¼" dia. if desired. Component parts can be re-used many times over. Jack receptacle is available in brass and aluminum . . . inside is insulated to prevent grounding effects. Terminal pins in connector are split and pre-set to produce clean wiping action each time contacts are engaged.



3- Aluminum panel board adaptor has drilled and tapped holes in flanges to permit fast installation. Will accommodate leadwire up to 16 ga. with overall insulation dimension to 7/32" diameter. Prepunched connector panels can be supplied.



FOR COMPLETE DETAILS AND PRICES

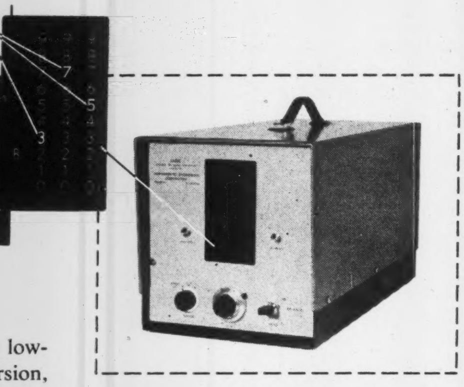
WRITE TODAY!

THERMO-COUPLE PRODUCTS COMPANY
1515 NORTH 25th AVE. • MELROSE PARK, ILL.
MFGRS. OF THERMOCOUPLES • CONNECTORS • CONNECTOR BOARDS

Please send me free literature without obligation.

NAME__________
FIRM__________
ADDRESS__________
CITY__________ STATE______

For more information circle **114** on inquiry card.



for precision indication

CEC's 33-110 SADIC digital voltmeter

Consolidated's newest unit for low-voltage analog-to-digital conversion, the 33-110 SADIC Digital Voltmeter offers true economy plus high accuracy...is useful both as a laboratory measuring device and as a building block for automatic data-processing systems. Dual output includes illuminated numerical display (above) and decimal-coded contact closures.

CONDENSED SPECIFICATIONS

digital range............000 to 999 (1000 steps)
accuracy..................1/10th% of full scale
sensitivity.......10 millivolts for full-scale output
balance time....................0.8 second, max.
power source..................105-115 volts a-c

Send today for complete details in Bulletin CEC 3002-X3.

Consolidated Electrodynamics
CORPORATION
formerly Consolidated Engineering Corporation
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
300 North Sierra Madre Villa, Pasadena, California
For more information circle **115** on inquiry card.

BORG
SERIES

Borg 900 Series Micropots
offer everything you want in a potentiometer

1 Versatility — 1 to 5 gang models, single or double shaft, servo or bushing mount.

2 Permanent Accuracy — Resistance element integrally molded within housing. Leads, taps and terminals firmly encapsulated.

3 Long Life — Scanning action distributes wear across face of bar contact. Rigid, fixed lead screw.

4 Dependability — Mechanically and electrically stable. Effectively sealed against dust and moisture.

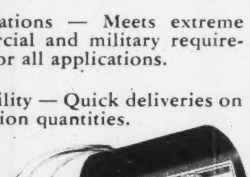
5 Absolute Linearity — Uniform resistance distribution. No external trimming required.

6 Specifications — Meets extreme commercial and military requirements for all applications.

7 Availability — Quick deliveries on production quantities.

Borg 1100 Series Micropots

Accurate, dependable, long-lived. Has 9 inch coded leads for easy installation. Offers your products a competitive price advantage.



WRITE FOR CATALOG BED-A15B
BORG EQUIPMENT DIVISION
GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

ELECTRONIC-MECHANICAL BORG EQUIPMENT

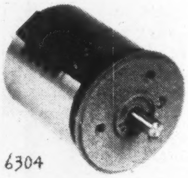
Built by Borg

For more information circle **116** on inquiry card.

metically sealed in metal cases. At 20-ma collector current, saturation voltage averages 1 v or less. Collector cutoff current is below 0.2 ua; collector dissipation at 135°C is 50 mw; maximum reverse emitter voltage is 22 volts. Power gains is a typical audio amplifier are 32 db for "CK790" and 34 db for "CK791." Current gains are 14× and 24× respectively.—*Raytheon Mfg. Co.*, 55 *Chapel St., Newton* 58, *Mass.*

For more information circle **427** on inquiry card.

TEN-TURN VDR



"Model 18-10 Potentiometer" is a 10-turn voltage-dividing resistor featuring linearities to 0.01%; Teflon shaft seal and high-leakage construction for leakage resistance consistent with linearity; linear or functional servo-controlled winding for high accuracy and low error rate.—*Analogue Controls, Inc.*, 39 *Roselle St., Minneola, N. Y.*

For more information circle **428** on inquiry card.

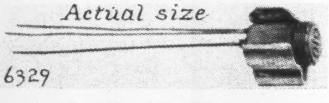
SINE-COSINE VDR

New "RVG-17XS" 1-1/16"-dia 1-½-oz precision voltage-dividing resistor producing true sine and cosine functions without complicated mechanisms has been designed for computer, navigational and control applications. It uses a uniformly-wound rectangular card on which true sine and cosine functions are picked up by four brush contacts. It can be operated at 60 rpm. Standard value 18,000 ohms; 4,000 to 25,000 ohms can be had. At higher resistance values, angular and amplitude accuracy is 1% and power rating is 1 watt at 40°C.—*The Gamewell Co., Newton Upper Falls* 64, *Mass.*

For more information circle **429** on inquiry card.

SUBMINIATURE VDR

New "Type 101-A Trimmer Potentiometer" is a "minimalized" component (i.e. one to two orders smaller than a "miniaturized" component). Among features: high stability of setting; dimensionally stable thermosetting plastic case; precious-metal sliding contact; several mounting combinations. Seven standard resistances from 680 to 6800 ohms (non-standard values can be supplied). Power dissipation is ¼-watt at 20°C. High resolution: minimum of 100 turns of resistance wire.—*Carter Mfg. Corp.*, 23 *Washington St., Hudson, Mass.*



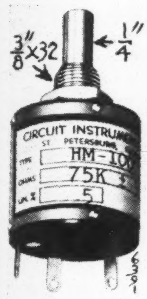
For more information circle **430** on inquiry card.

PRECISION VDR

New "Model RVG-10" miniature (5/8" dia, 3/8 oz.) voltage-dividing resistor, for severe-duty applications involving high temperatures and vibrations, is available in single and multi-gang constructions; with winding resistances from 20 to 30,000 ohms; minimum resolution of 0.09% and linearity of 0.25% where specified; maximum continuous operating temperature 150°C (302°F). Meets MIL-E-5272A.—*The Gamewell Co., Newton Upper Falls 64, Mass.*

For more information circle **431** on inquiry card.

MULTI-TURN VDR

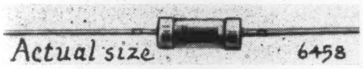


New miniature "Model HM-100," similar in construction and general characteristics to maker's standard ten-turn voltage-dividing resistor, is available with flexible or turret type terminals; 1 oz-in maximum starting torque; weight 1.2 oz; 1" case diam; rated at 2 watts at 40°C; standard linearity 0.5%; resistance values 500 to 100,000 ohms.—*Circuit Instruments Inc., P.O. Box 355, St. Petersburg, Florida.*

For more information circle **432** on inquiry card.

CARBON-FILM RESISTOR

New "PT 500" glass-sealed carbon-film resistor features extreme ruggedness, and exceptional high stability

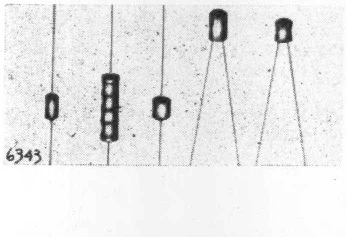


of better than 0.03% per year at 0.25-watt rating and derating to zero power at 140°C. Using 0.5-watt rating, derating to zero at 160°C, stability is better than 0.1% in 1000 hours. Resistance values from 1 ohm to 2 megohms. Available in sets with temperature coefficients matched to 1 ppm/C° for high-precision use over wide temperature ranges.—*Pyrofilm Resistor Co., Inc., 8 Whippany St., Morristown, N. J.*

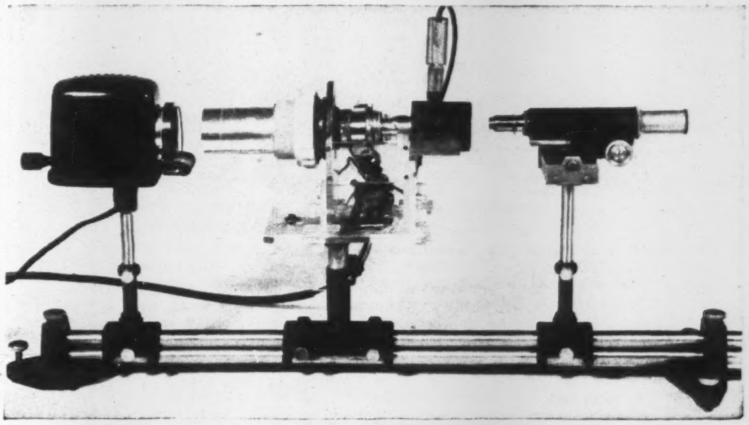
For more information circle **433** on inquiry card.

SUBMINIATURE RESISTORS

New subminiature encapsulated resistors feature a new winding technique which permits use of extremely fine resistance wire to obtain two or



A NEW APPROACH TO THE PROBLEMS OF INSTRUMENTATION



THE Meyer UNIVERSAL INSTRUMENT BENCH

THE PROBLEM → TO PROVE OUT AND TEST INSTRUMENT SYSTEMS IN: OPTICS, ELECTRONICS, PHYSICS, PHOTOGRAPHY, ELECTRO-MECHANICS, AND ALLIED FIELDS.

THE APPROACH → BY THE USE OF OVER 50 COMPONENTS WHICH CAN BE ASSEMBLED IN THOUSANDS OF COMBINATIONS. WITH ANY NUMBER OF THESE COMPONENTS A TREMENDOUS RANGE OF INSTRUMENTATION SETUPS CAN BE MADE IN A MATTER OF MINUTES.

THE SOLUTION → THE ILLUSTRATION SHOWS A SET-UP FOR TESTING THE IMAGE QUALITY OF AN ELECTRON TUBE OR THE OPTICAL PROPERTIES OF A LENS.

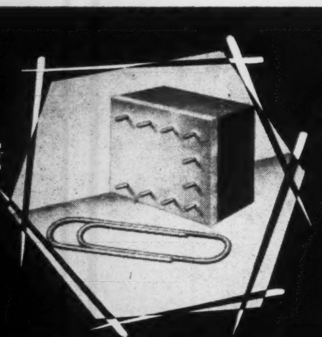
AREAS OF APPLICATION →
FOR RESEARCH AND DEVELOPMENT
ON THE PRODUCTION LINE
IN ASSEMBLY AND INSPECTION
INDUSTRIAL PHOTOGRAPHY

For a complete 20 page descriptive catalogue send to

Meyer-Opticraft, Inc.
(Formerly Hugo Meyer & Co.)
39 West 60th St. New York 23, N. Y.

For more information circle **117** on inquiry card.

New!
SUBMINIATURE MAGNETIC STORAGE ELEMENTS BY



EPSCO

SMALL SIZE • LOW POWER • RUGGEDNESS • RELIABILITY

New Magnetic Storage Elements Type SR-11 are designed for airborne and missile applications. Due to their extremely low power requirement, they may be driven by either sub-miniature tubes or transistors.

Measuring only ¾" x ¾" x 7⁄16", these new subminiature units are entirely suitable for mounting on etched wiring boards. Epsco SR-11 storage elements also offer the advantages of high ratio of storage elements to drive tubes. Wide operating limits and encapsulated packaging insure the ultimate in reliable performance.

SR-11 elements have an information rate design center of 10 kc, with a practical upper information rate of 15 kc. Peak power per shifted "one" at design center is only 0.5 watts.

EPSCO INCORPORATED

WRITE FOR ENGINEERING DATA SHEETS. . . .

588 Commonwealth Avenue, Boston 15, Mass.

For more information circle **118** on inquiry card.

STEREO—MICROSCOPE

With novel rapid change of magnification from 6x to 160x with wide-angle oculars.

Large working distance from 3¾-in., with diameter of object field up to 32mm. Beyond 80x magnification, the working distance is 1⅝-inch.

Uniform sharpness over the entire field of view. Erect, non-reversed image. Outstanding plasticity; easy on the eyes even during prolonged observation.

Write for Literature

CARL ZEISS, INC.
485 Fifth Avenue
New York 17, N.Y.

Guaranteed Uninterrupted Repair Service

CARL ZEISS

MADE IN WEST GERMANY

For more information circle **119** on inquiry card.

three times resistance value previously supplied on a miniature bobbin. Units can operate at 125° C continuous power without de-rating; meet or exceed MIL-R-93A, amdt 3; can be obtained in tolerances as close as 0.05%.—*The Daven Company, 530 W. Mt. Pleasant Ave., Route 10, Livingston, N. J.*

For more information circle **434** on inquiry card.

WIRE-WOUND RESISTORS

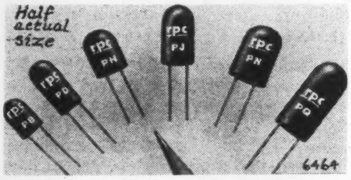
New "M" series miniature (⅜" OD) and "SM" subminiature series (¼" OD) precision wire-wound resistors fill the need for lead mounting in printed circuitry or crowded chassis requirements. Ratings from 0.1. to 2.5 watts and ohmic values up to 2.5 megohm.—*Reon Resistor Corp., 117 Stanley Ave., Yonkers, N. Y.*

6463

For more information circle **435** on inquiry card.

MINIATURE RESISTORS

New "Type P" precision wire-wound miniature resistors are single-ended units made for rapid mounting on graphic circuit panels with no support other than wire leads; can be safely operated at full rated load in ambient temperatures up to 125°C. Ratings from 0.1 watt to 1 watt; resistances from 0.4 megohm to 3 megohms; tolerances from 1% to 0.05%. —*Resistance Products Co., 914 S. 13th St., Harrisburg, Pa.*

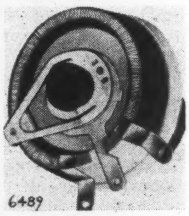


6464

For more information circle **436** on inquiry card.

RING RHEOSTAT

New "Type N152" 50-watt ring type rheostat is designed specifically for use in control equipment where severe mechanical shock is encountered; meets MIL-R-15109 and Hi-Shock requirements of MIL-S-901. Among features: Shock-resistant (Class HI) Class C insulation; "twin contact shoes" designed for smooth operation and minimum wear on resistance wire. Max. resistance value 20,000 ohms.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*



6489

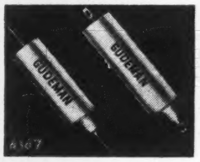
For more information circle **437** on inquiry card.

VOLTAGE-SENSITIVE CERAMIC CAPACITORS

New "Types LVSR and LVSE" are voltage-sensitive ceramic capacitors with lowered capacitance values that range from 300 mmf down to 100 mmf for those applications where maker's "Type VSR and VSE" are not low enough. Their capacitance can be decreased as much as 60% by application of direct potential up to 200 v. They are temperature-sensitive; "LSVR" has maximum voltage sensitivity at room temperature and "LVSE" at about 70°C. Both are housed in a steatite tube about 7/32" dia and about ½" long; and have #26 gage leads.—*Mucon Corp., 9 St. Francis St., Newark 5, N. J.*

For more information circle **438** on inquiry card.

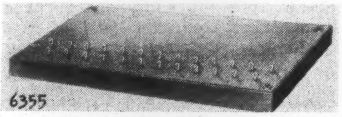
MINIATURE CAPACITORS



New miniature paper-dielectric hermetically-sealed feed-through capacitors for use in rf interference suppression feature functional performance "as near as possible to an ideal capacitor due to the internal construction which is designed to minimize the inherent inductance."—*Gudeman Co., 340 W. Huron St., Chicago 10, Ill.*

For more information circle **439** on inquiry card.

DELAY UNITS

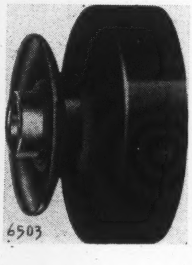


New custom-built "Portable PTM Multiplex Communication System Delay Lines" feature a combination of characteristics said to be "unique and outstanding": 125-usec delay; 3300-ohm impedance; 1% accuracy; tapped in increments of 5.2 usec; meets all application MIL specs.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **440** on inquiry card.

ELECTROMECHANICAL COMPONENTS

AUTOMATIC CLUTCH FOR FRACTIONAL-HP MOTORS



New "Mercury 305" a low-priced automatic clutch for 1/6, ¼ and 1/3 hp electric motors is recommended for original equipment on FHP-powered devices. It minimizes length of sustained inrush

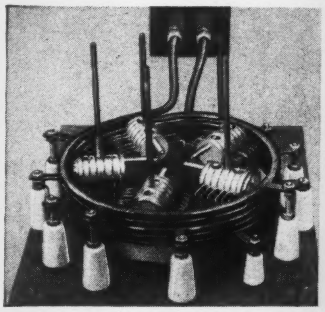
BRAZING
HARDENING
BOMBARDING
SOLDERING
ANNEALING
MELTING

Lepel
HIGH FREQUENCY
Induction
HEATING
UNITS

The Lepel line of Induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.

TYPICAL INDUCTION HEATING APPLICATIONS



A widely used application in which several assemblies, consisting of a brass body, six radiator fins and a mounting stud, are being soldered simultaneously. The production of similar parts can be further increased by using two work coils and a change-over switch.

The illustration shows a lens grinding block being heated within the dome-shaped work coil. The heat generated in the metal block softens the pitch enabling the operator to remove the ground lenses and insert the next batch. The entire operation is completed in a few seconds.

Electronic Tube Generators—1 KW; 2½KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.
Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

For more information circle **120** on inquiry card.

CONTROL SYSTEMS for INDUSTRY

first FOR MILLS

FOR SOAKING PIT COVERS

Automatic removal of soaking pit covers from crane cab or floor.

REMOTE CRANE CONTROL

Automatic operation of hoist and crane from plant floor.

FOR MANY APPLICATIONS

Control systems for safeguarding lives, signalling, monitoring, etc.

Femco engineered remote control systems save time, cut costs, increase production and promote safety. Get the facts. Submit your problem for a proposal.

Femco Inc.
IRWIN, PENNSYLVANIA
UNderhill 3-3200

For more information circle **121** on inquiry card.

COUNT CANDY OR CARTONS?

there's an ATOMIC counter or controller for the job

The widest variety of counting models available . . . decade or duodecade types . . . speeds up to 2000 c.p.s. for controllers, up to 20,000 c.p.s. for counters . . . straight totalizing counters, single or dual preset controllers provide wide versatility for production control.

Atomic's Functional Plug-In Strips provide complete instruments for specialized requirements . . . eliminate costly "custom-design" charges. Strip construction, using low-current, low-heat glow transfer tubes simplifies circuitry . . . provides extreme reliability. Plug-in replacement of strips eliminates downtime . . . keeps production rolling.

Write today for new catalog B — just off the press.

See our display at Booths 323-25 — I.R.E. Show.

ATOMIC INSTRUMENT COMPANY
84 MASSACHUSETTS AVE. CAMBRIDGE 39, MASS.

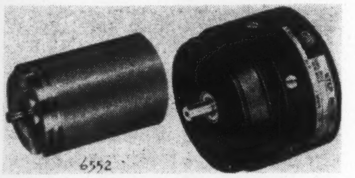
For more information circle **122** on inquiry card.

current by permitting motor to reach full speed before any load is applied. It assures smooth acceleration and transmits full power without slippage. —*Automatic Steel Products, Inc., Canton, Ohio.*

For more information circle **441** on inquiry card.

STEP MOTOR

New "Model 306" step motor (right) has three salient field poles and four armature poles. As fields are energized singly and in pairs in a sequence determined by transmitter (left), rotor follows transmitter in steps. Motor reverses without overshoot when transmitter reverses, even at maximal speed; has much greater torque for its size than a synchro. No torque is reflected to transmitter even when several motors are operated from one transmitter. Max speed 150 rpm; stalled torque 20 oz-in; steps 15°; operates on 115 vdc, no need of electronic or magnetic amplifiers.—*Gap Instrument Co., 253 W. Merrick Rd., Valley Stream, L. I., N. Y.*



For more information circle **442** on inquiry card.

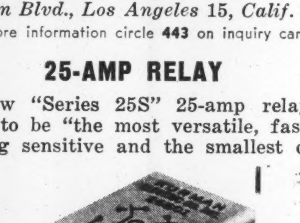
1600-CPS COMPONENTS

New 1600-cps components for use in advanced computer designs, radar equipment, etc., include drive motors (1.45" frame), servomotor tachometers (sizes 18 and 15), and resolvers (sizes 23, 15 and 11). New 1600 cps motor-alternators are available for supplying power for testing these and other 1600-cps components.—*American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.*

For more information circle **443** on inquiry card.

25-AMP RELAY

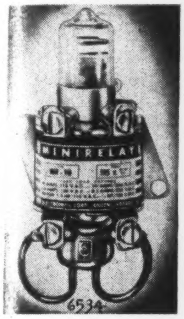
New "Series 25S" 25-amp relay, said to be "the most versatile, fast-acting sensitive and the smallest of



its type," features ac or dc operation, 250,000 operations minimum life with full contact load of 25 amp 125 vac resistive or 1,000,000 with load of 5 amp 125 vac resistive. It is fast-acting (0.004 sec) with 2 watt input (dc only); meets MIL-R-5757B Class A.—*Kurman Electric Co., Inc.*, 35-18 37*th St., Long Island City, N. Y.*

For more information circle **444** on inquiry card.

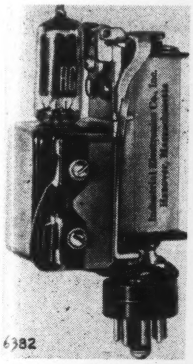
MERCURY-PLUNGER RELAY


MINIRELAY
6534

New "Minirelay," said to be "the smallest Mercury Plunger Relay on the market," is capable of handling any load up to 20 amp or 1.5 hp. at 115 v, 50/60 cps; has an extremely fast action (about 30 millisec) to make or break. It is said to have "all the advantages of standard 35-amp and heavy-duty 60-amp mercury relays in a unit less than half their size."—*Ebert Electronics Corp.*, 212-23 *Jamaica Ave., Queens Village* 28, *N. Y.*

For more information circle **445** on inquiry card.

SENSITIVE RELAY

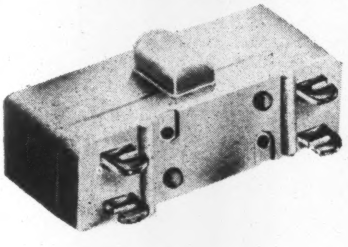


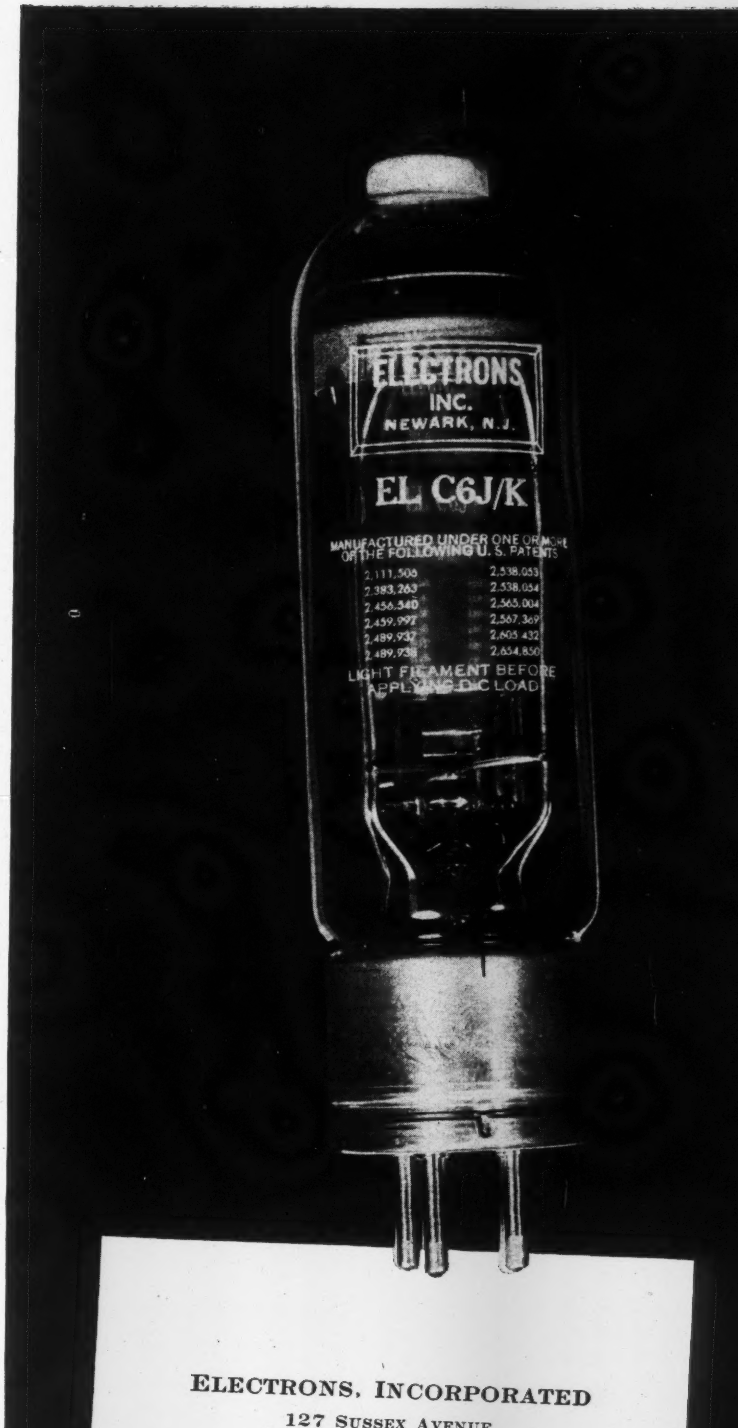
New "Series 3000 Super-Sensitive Electronic Relay" can operate on less than 15 uamp; has power amplification of about 10 million: input power less than 0.00011 watt and output circuit can carry up to 1150 watts. Makers recommend it for control of level, temperature or pressure, or to measure movements of delicate devices.—*Industrial Electronics Co., Inc., Hanover, Mass.*

For more information circle **446** on inquiry card.

40-AMP SWITCH

New "Model G3-8," for motor control and automation setups, measures 1¾" x 43/64" x 43/64", yet can handle 40 amp, because of new method of combining double-break feature of

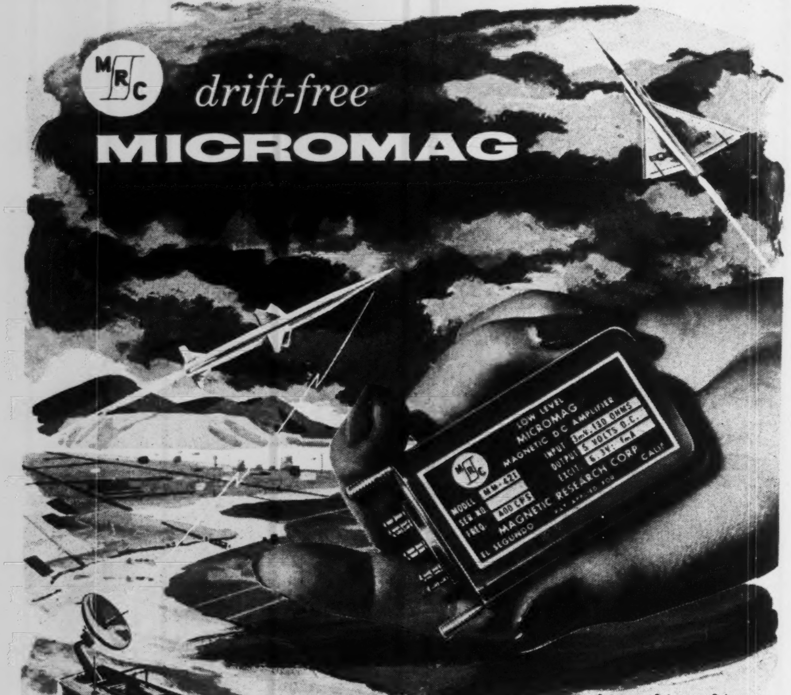



ELECTRONS
INC.
NEWARK, N.J.
EL C6J/K
MANUFACTURED UNDER ONE OR MORE OF THE FOLLOWING U. S. PATENTS
2,111,506 2,538,053
2,383,263 2,538,054
2,456,540 2,565,004
2,459,997 2,567,369
2,489,937 2,605,432
2,489,938 2,654,850
LIGHT FILAMENT BEFORE APPLYING D-C LOAD

ELECTRONS, INCORPORATED
127 Sussex Avenue
Newark 3, N. J.

This new 6.4 amp. Xenon thyratron can be used with any type of load, without additional "cushion circuits."

For more information circle **123** on inquiry card.



size: 1¼" x 1½" x 2⅜"
weight: less than 7 oz.

LOW-LEVEL MAGNETIC D. C. SIGNAL AMPLIFIER

for thermocouple and strain gage applications in telemetering systems

RUGGED, ALL-MAGNETIC construction assures exceptional stability under the most severe conditions. No moving parts, no fragile elements. Unit withstands extreme vibration and shock without introducing spurious noise, and delivers reliable performance in high environmental temperatures. Produces 5 VDC output from 1 millivolt DC input, with exceedingly high gain stability. Used in all major aircraft and missile instrumentation projects as well as for temperature and strain measurements in industrial and medical applications.

FEATURES

- Gain change of less than 2% for temperature change of 100° C.
- Gain change of less than ½% for line voltage changes from 105 to 125 volts.
- High DC voltage gain, ripple-free. 5 VDC output from 1 millivolt DC input.
- Responds only to DC; signal sensitivity 10^{-12} watts
- No pickup — no lead shielding required.
- All magnetic — maintenance-free.
- Response time 40 milliseconds.
- No tubes — no warm-up time, generates no heat.
- Power requirements less than 10 milliwatts.
- Temperature compensated control circuit.
- Hermetically sealed in thermosetting plastic.
- Magnetically shielded.
- Long life, extremely rugged and reliable.
- Operates from standard 400-cycle supply.

for further information, write for Bulletin EB-201-A

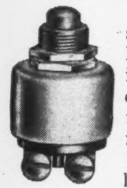
MAGNETIC RESEARCH CORP.
200 CENTER STREET • EL SEGUNDO, CALIFORNIA
Mfrs. of Magnetic Amplifiers and Converters, Magnetically Regulated DC Power Supplies, Magnetic Pulse Generators.

For more information circle **124** on inquiry card.

maker's basic switch with a heavy-duty switching element. Switch case is a new plastic for higher temperature rating and extreme resistance to shock. Operating force 30 oz.—*Electro-Snap Switch & Mfg. Co., 4218-30 W. Lake St., Chicago 24, Ill.*

For more information circle **447** on inquiry card.

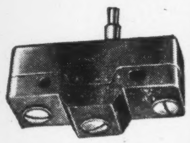
PANEL-MOUNT SNAP-SWITCH



New push button snap-switch, of type commonly called a "nut" switch, is advantageous for panel mounting: only one round hole to drill. Rating is 12 amps, 125 v, ½ hp; Underwriters listed. Optional terminals include screw, solder or quick disconnect.—*Acro Mfg. Co., Columbus 16, Ohio.*

For more information circle **448** on inquiry card.

"STEP-BASE" SNAP-SWITCH

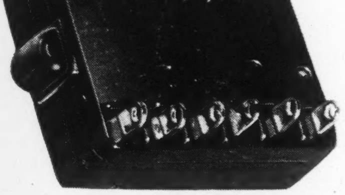


New version of maker's basic "C" switch has a raised pad at midpoint of base. Open terminal is positioned on this pad; closed and common terminals are at opposite ends of base and at a lower level. Design simplifies wiring to terminals; cuts costs.—*Acro Mfg. Co., Columbus 16, Ohio.*

For more information circle **449** on inquiry card.

SIX-CIRCUIT SWITCH

New "Model K3-4" triple-pole snap-action switch controls six circuits from a single actuation. It simultaneously reverses current flow through two windings of a 3-phase motor up to 1 hp or other type of multi-switching installations. Rating: 15 amp @ 125/250 vac; 15 amp @ 30 vdc res.—*Electro-Snap Switch & Mfg. Co., 421 W. Lake St., Chicago 23, Ill.*



For more information circle **450** on inquiry card.

PUSH-BUTTON ACTUATORS FOR SWITCHES

New "4MA and 5MA Series" push button actuators for snap-action switches are especially useful in elec-

MILFORD

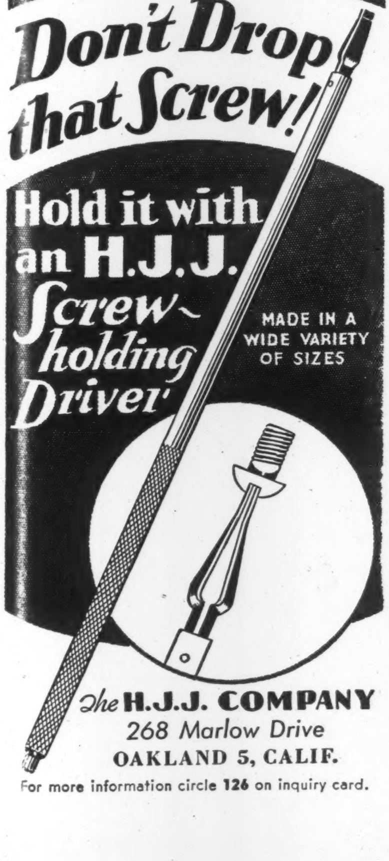
TUBULAR RIVETS
SPLIT RIVETS
COLD-FORMED SPECIALTIES
RIVET-SETTING MACHINES

MILFORD
m
RIVET

THE
MILFORD
RIVET & MACHINE CO.

PLANTS: MILFORD, CONNECTICUT
HATBORO, PENNSYLVANIA • ELYRIA, OHIO
AURORA, ILLINOIS • NORWALK, CALIFORNIA

For more information circle 125 on inquiry card.



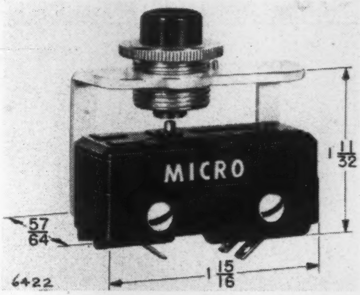
Don't Drop that Screw!

Hold it with an H.J.J. Screw-holding Driver

MADE IN A WIDE VARIETY OF SIZES

The H.J.J. COMPANY
268 Marlow Drive
OAKLAND 5, CALIF.

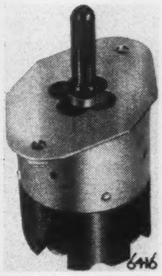
For more information circle 126 on inquiry card.



trical computers and similar devices; can be mounted through panels 1/16" to ⅛" thick.—*Micro Switch, Freeport, Illinois.*

For more information circle **451** on inquiry card.

4-T M-C TOGGLE SWITCH

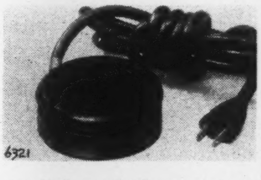


New "5050 Series" heavy-duty toggle switch for military and industrial uses is a momentary-contact four-throw single-pole center-off unit with a snap feel. It is internally sealed with a silicone boot that keeps moisture and dust away from contacts. These wiping contacts continue to open and close despite pitting and corrosion on their surfaces and will not weld under current as high as 200 amp. Switch is rated 20 amp inductive (AN 3179) 28 vdc for 10,000 cycles; 15 amps inductive 28 vdc for 50,000 cycles.—*Mason Electric Corp., 3839 Verdugo Rd., Los Angeles Calif.*

For more information circle **452** on inquiry card.

FOOT SWITCH

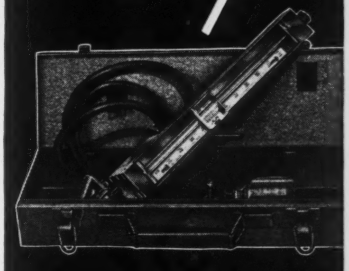
New "circumference-actuated" electrical foot switch, unlike conventional foot switches, makes positive contact wherever it is pushed—on top, or anywhere on its circumference (can also be actuated with hand, elbow, or knee). Two switches can be placed in series for safety: placed so that both hands must be used to operate a punch press, etc.—*The Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif.*



For more information circle **453** on inquiry card.

ROTARY SELECTOR SWITCHES

New rotary selector switches for either thermocouple or resistance bulb circuits, and for flush panel or wall



UNMATCHED ACCURACY

in a package

Everything you need . . . for field instrument calibration

MERIAM Manometer Kits
★ Magnifying sight glass
★ Mirror for resolving parallax
★ Built-in level indicator
★ Precision-bore pyrex tubing
★ Built-in fluid seal
★ All stainless steel construction

Write for Bulletin B-2862.

Meriam Manometer Instrumentation
. . . for pressures, vacuums, flows, liquid levels.

meriam
INSTRUMENT COMPANY
10920 Madison Ave. • Cleveland 2, Ohio

For more information circle 127 on inquiry card.

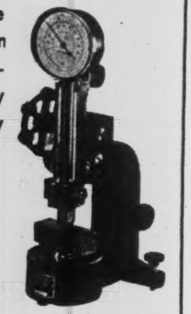
HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 50 years.

In general use for specification purposes. Simple, sturdy Comparatively inexpensive.

•

Illustrated bulletins free



The Shore Instrument & Mfg. Co., Inc.

90-35 Van Wyck Expressway
Jamaica 35, N. Y.

For more information circle **128** on inquiry card.

High Precision OPTICAL COMPONENTS Any Size For Astronomical and Physical Research

•

Parabolic, Spherical, Ellipsoidal and Plane MIRRORS

•

Plane Parallel PLATES

•

SCHLIEREN SYSTEMS

•

Wind Tunnel OPTICS

•

LENSES & PRISMS of Glass Natural or Synthetic CRYSTALS

•

Complete Optical and Mechanical INSTRUMENTS

•

Made to Specifications

•

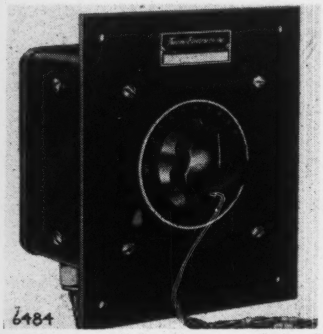
High Vacuum Coating

•

John Unertl Optical Co.

3551-3555 East Street
Pittsburgh 14, Penna.

For more information circle **129** on inquiry card.



mounting, are "shorting-type" (make-before-break) double-pole switches, with contacts and wipers of the same silver alloy to minimize possibility of false emfs. Three models are stocked: OFF to 6-point, OFF to 12-point and OFF to 24- point.—*Thermo Electric Co., Inc., Rochelle Park P.O., Saddle Brook, N. J.*

For more information circle **454** on inquiry card.

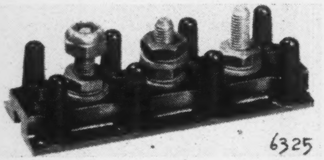
ALARM LAMP AND RELAY

New "RBE-170D" combination indicating lamp and relay alarm unit mounts in a 1⅜" diameter hole. Its anti-dust container holds up to three relays each with 3p-dt contact capacity. Wire leads can be fitted with various plug-in devices. ★Also available: plug-in relay panels completely wired to order with terminal blocks, fuses, etc., grill type rectangle frame with engraved message plates, etc.—*H. R. Kirkland Co., Morristown, N. J.*

For more information circle **455** on inquiry card.

TERMINAL STRIPS

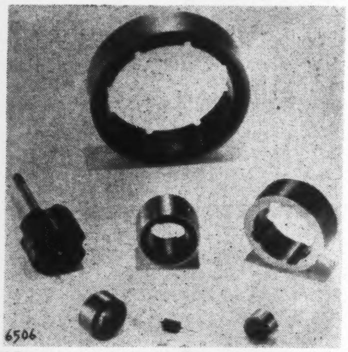
New terminal strips featuring post-type barriers and studs, for attachment of single or multiple terminal-ended or looped wires, provide extremely compact light-weight units said to be readily adaptable to varying wiring requirements. Available with #6 studs in 1 through 20 circuits, with #8 or #10 studs in 1 through 16 circuits, and with ¼", 5/16" and ⅜" studs in 1 through 8 circuits. Various molding compounds, either MIL specs or commercial grades; various types of hardware (see photo), base cuts, insulating strips and bus strips.—*Buchanan Electrical Products Corp., Hillside, N. J.*



For more information circle **456** on inquiry card.

PLASTIC-BOUND MAGNETS

New pressed-plastic-bound permanent magnets result from a new method of manufacture that makes it possible to press shafts, temperature-compensation pieces, etc., into magnets, or to make magnets of intricate designs on a mass production basis. All machining is eliminated. Other claims include "highest precision magnetic tolerances; lower aging requirements and, where applicable, cost reduction of entire magnet systems."—*Baermann-Nord Corp., Amherst, Ohio.*



For more information circle **457** on inquiry card.

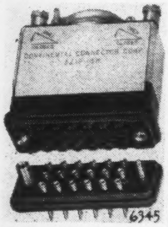
CARTRIDGE HEATING UNIT

New "Firerod" produces five times more heat than any standard unit of similar size, "plus a longer cartridge life." High rate of heat transfer from resistance wire to dissipating surface results from lessened differences between wire temperature and sheath temperature. A "Firerod" has been operated in open air for periods up to 720 hours at a sheath temperature of 1800°F. "A standard unit of comparable size would last only minutes." Available in standard, moistureproof, and special units, 1¼" to 12" L and ⅜" or ½" OD.—*Watlow Electric Mfg. Co., 1376 Ferguson Ave., St. Louis 14, Mo.*

For more information circle **458** on inquiry card.

POLARIZING SCREWLOCKS FOR CONNECTORS

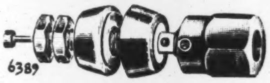
New "Continental E-Z Release" power connectors can be supplied with polarizing screwlock feature to provide a positive mechanical means of locking plug and receptacle against vibration or accidental disconnection. "Series E-Z 16" available in 12, 18, 24 and 34 contacts with solder cup for #16 AWG wire or solderless wiring taper pin for "AMP Series 53."—*DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.*



For more information circle **459** on inquiry card.

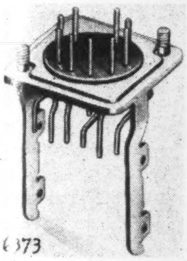
MULTI-WAY BINDING POST

New "No. 640" binding post permitting six different methods of above-panel connection and three below-panel connections; is of nickel-plated brass; rated at 30 amp, 1000 v; designed for low-capacitance type mounting on metallic panels 1/16" to ¼" thick.—*Insuline Corp. of America, 186 Granite St., Manchester, N. H.*



For more information circle **460** on inquiry card.

RELAY HEADER ASSEMBLY



New hermetically-sealed Relay Header Assembly simplifies production techniques by eliminating: (1) buying or producing square cover plates with studs attached; (2) stamping hole in cover plate for hermetically sealed header; (3) attaching and shaping pigtails; (4) soldering or brazing mounting bracket to cover plate; (5) mounting seal in cover plate.—*Hermetic Seal Products Co., 29-37 S. Sixth St., Newark 7, N. J.*

For more information circle **461** on inquiry card.

MECHANICAL COMPONENTS

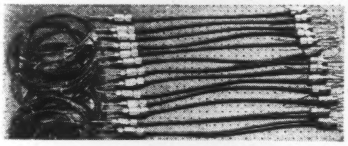
AIR CYLINDERS

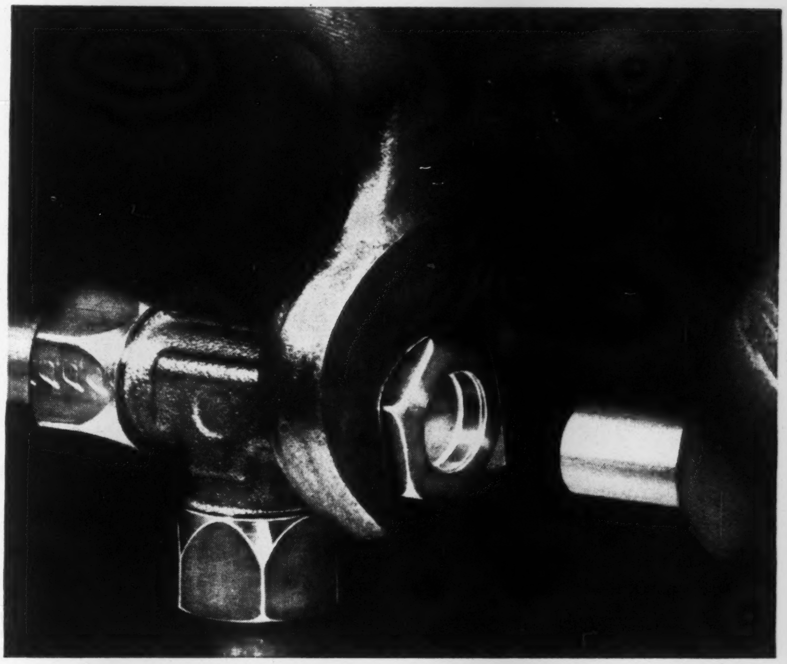
New "Seal-Off" air cylinders for air-powered equipment are available in three basic styles: standard, adjustable and adjustable-retractable. These, with six types of mounting and either single or double rod type, insure a standard cylinder for every need. —*Taylor-Winfield Corp., Warren, Ohio.*

For more information circle **462** on inquiry card.

TUBING ASSEMBLIES

New "Flex-tube Assemblies" include neoprene-covered flexible tubing factory assembled with end fittings having standard male or female pipe-thread connections. UL-approved tubing is galvanized steel or brass, interlock construction with an over-all neoprene cover, whence permanent leak-tight and vapor-proof protection against oil, grease, water, chemicals,

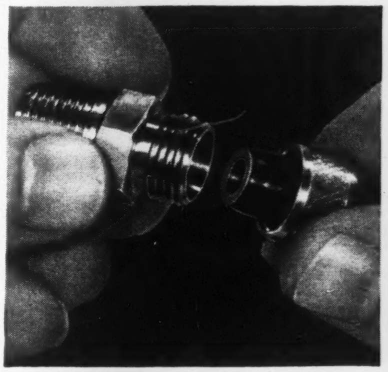




Simply push, then tighten! Anyone can quickly install all-new, *lightweight Intru-lok* tube fittings . . . the proven Parker 3-piece flareless design. Just insert the tube, then tighten the nut with a regular wrench . . . for a leakproof, vibration-proof joint. Made of brass for copper or nylon tubing. Send for complete details in Catalog 4324.

Introducing easy-to-use

PARKER INTRU-LOK



For soft plastic tubing you use knurled nut and expander insert with new *Intru-lok* body. Joints can be disconnected and reassembled. Complete details in Catalog 4324. Send for it.

Weld-lok fittings, for extreme temperatures, corrosion conditions . . . machined from high-quality steel or stainless bar stock and forgings . . . for tubing ¼" through 2" O.D.

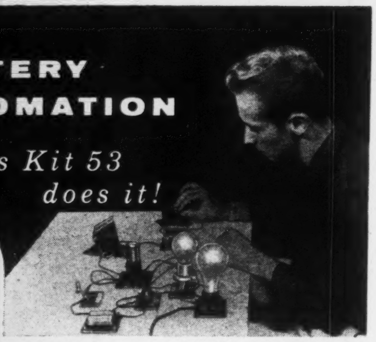
TUBE AND HOSE FITTINGS DIVISION
Section 415-Q
The Parker Appliance Company • 17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid
system components

For more information circle **130** on inquiry card.

TAKE THE MYSTERY OUT OF AUTOMATION

new Crow Electronics Kit 53 does it!



Automation is becoming a scare word to many factory workers. Their resentment of complex electronic machinery stems from inability to understand its operation. Left unchecked, this attitude can create serious morale problems.

Understanding Promotes Acceptance— Crow Electri-Craft has come up with a sensible and inexpensive solution to this problem. It's the new "visual experiment" kit—Electronic, Tubes, Circuits and Devices (Model 53).

This "learn-by-doing" kit is designed to fit right into your employee training program . . . to explain the fascinating world of Electron Tube Theory, Radio Transmitting and Receiving, Radar, and Industrial Electronic Controls.

A Complete "Package"—Model 53 contains 108 quality components, everything needed to perform 73 related experiments. Students build their own operating assemblies—magnetic amplifiers, multi vibrators, photo electric controls, electronic counting circuits, and many more.

Easy to Understand—An illustrated 400-page manual shows how to build each assembly, discusses the theory involved and its practical application. No mathematical formulas . . . directions are so clear that the kits can even be used for self-instruction at home.

Model 53 is the latest in a series of low-cost kits developed by Crow to meet the growing need for widespread electrical and electronic knowledge. Crow Kits make these vital subjects easy to teach . . . exciting to learn.

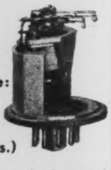
Write for illustrated folder giving full details.

CROW ELECTRI-CRAFT CORP.
DIVISION OF UNIVERSAL SCIENTIFIC CO., INC.

Box 336W
Vincennes,
Indiana

For more information circle 131 on inquiry card.

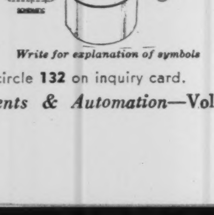
VHS* RELAY
(*Very High Sensitivity)



Model 266

Sample specs. are: 0.2 micro-amperes, (12,000 ohms coil) or, 0.1 millivolts, (5 ohms.)

• The VHS is a balanced armature, Alnico magnet type relay. It is internally shock-mounted and resistant to vibration. The screw-on cover is gasket sealed. It can be opened and resealed. Connections: 9 pin octal style. Dimensions: 1¾ diameter x 2¼ long. Weight: 4 ounces. Sensitivity: Infinite variations from 0.2 Ua. to 10 Amp. or 0.1 Mv. to 500 volts, self contained. Higher volts or amps with external multipliers. A.C. rectifier types. Trip point accuracies to 1%. Differential 1%. The degree of resistance to shock and vibration primarily depends upon sensitivity and type of action wanted. In general, the relays will not be permanently damaged by shocks of 100 G's and vibrations up to 2,000 cps at 3-4 G's. Most sensitive relays may close their contacts under these conditions. Contacts: SPST or SPDT, 5-25 Ma. D.C. Other ratings to ½ Amp. A.C. A locking coil gives high pressure and chatter free contact under shock and vibration. Prices Prices: $20 - $80. Delivery 4 to 6 weeks. Assembly Products, Inc., Chesterland 10, Ohio.



Write for explanation of symbols

For more information circle 132 on inquiry card.

King

MANOMETERS
Every Size - for Every Service

U-Type Manometers
- Single Cleanout
- Single Gland-Packed
- Double Cleanout
- Double Gland-Packed
- High Pressure

Well-Type Manometers
- Low Well
- Raised Well
- Barometric Reading

Multi-Tube Manometers
- Multi-Well
- Common-Well
- Special-Purpose

FREE LITERATURE gives sizes, construction and prices. Write today! And ask for informative 12-page Manual on Manometers.

KING ENGINEERING PRODUCTS include King-Gages — Pressure Transmitters — Sight Feed Bubblers — Overflow Check Valves — Air Flow Snubbers — Moisture Indicators

KING ENGINEERING CORP.
Box 70 • Ann Arbor, Mich.
REPRESENTATIVES IN PRINCIPAL CITIES

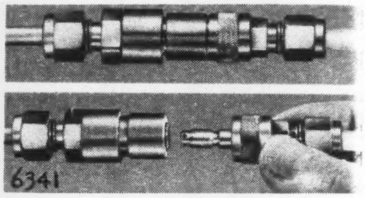
For more information circle 133 on inquiry card.

corrosive fumes, etc. Made in several standard lengths and available in any required length for special application. Photo shows assemblies equipped with "Packing Glands" at right and "Thermocouple Glands" at left with coils of tagged lead wires.—*Conax Corp.*, 781 *Sheridan Drive, Buffalo* 21, *N. Y.*

For more information circle **463** on inquiry card

QUICK-CONNECT FITTING

New "Swagelok" quick-connect fitting is connected and disconnected with thumb and finger as "tools"; incorporates shutoff valve as a positive seal. Used with plastic tubing and metal tubing, new fittings are available in all metals, in sizes to fit ordinary applications and in 3 types: (1) tube-to-tube with "Swagelok" ends; (2) tube-to-pipe with one "Swagelok" end; (3) bulkhead, either tube-to-tube or tube-to-pipe.—*Crawford Fitting Co.*, 884 *East* 140*th St., Cleveland* 10, *Ohio.*

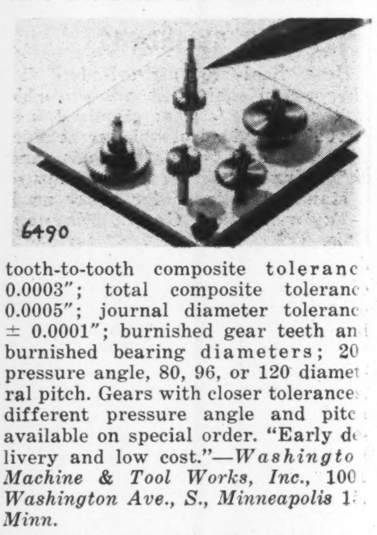


6341

For more information circle **464** on inquiry card

MINIATURE GEARS

New extremely precise miniature gears offer the following extremely close tolerances and characteristics: tooth-to-tooth composite tolerance 0.0003"; total composite tolerance 0.0005"; journal diameter tolerance ± 0.0001"; burnished gear teeth and burnished bearing diameters; 20 pressure angle, 80, 96, or 120 diametral pitch. Gears with closer tolerances, different pressure angle and pitch available on special order. "Early delivery and low cost."—*Washington Machine & Tool Works, Inc.,* 100 *Washington Ave., S., Minneapolis* 1 *Minn.*

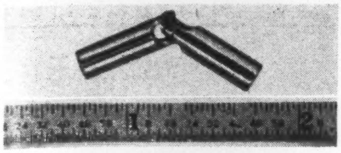


6490

For more information circle **465** on inquiry card

MINIATURE UNIVERSAL JOINT

New "Mini-Joint," for use in instrumentation equipment or other systems operating at low mechanical power levels, permit flexible design in solid shaft connections common wit

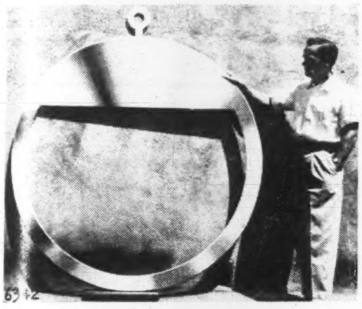


small synchros, resolvers, small motors, indicator repeaters, etc. Preloaded bearing surfaces (ground and lapped balls) give continuous contact with zero backlash and low friction. Body diameters 3/16" to ⅜"; lengths 1¼" and 1½" over-all.—*Falcon Machine & Tool Co., 209 Concord Turnpike, Cambridge 40, Mass.*

For more information circle **466** on inquiry card.

SEGMENTAL ORIFICE

New 60" segmental orifice plate pictured is built of ¼" thick stainless steel, for coke oven gas measurement.



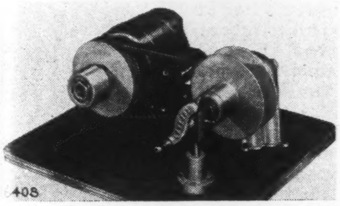
6342

This type of plate is used where foreign substances or liquids are present in piped gases.—*Daniel Orifice Fitting Co., Inc., 3352 Union Pacific Ave., Los Angeles 23, Calif.*

For more information circle **467** on inquiry card.

VARIABLE SPEED PULLEY

New compound drive provides constant belt alignment through its entire speed range up to 8-to-1 ratio.



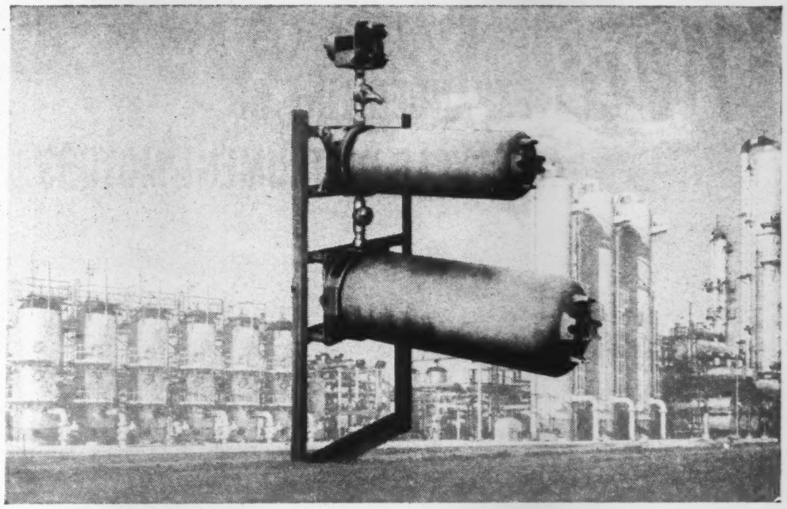
408

Using a 1750-rpm motor a speed range of 5550 to 690 is obtained at a rated ¾ hp; with an 1150-rpm motor, 3650 to 454 at ½ hp. Over-all dimensions: Where mounted on one side, spring-loaded design 6½" OD by 5" long, manually-operated design 6" OD by 3⅜" long. Mounted alternately, 6" OD by 3⅞" long and 6" OD by 3⅜" long respectively.—*Lovejoy Flexible Coupling Co., 4907 W. Lake St., Chicago 44, Ill.*

For more information circle **468** on inquiry card.

DIFFERENTIAL KIT

New "Type #V1, V4 & V7" universal differential kits come complete with a wide range of interchangeable



The BICHROMATOR® Infrared Analyzer

Designed for Continuous Gas and Liquid Analysis Under Plant Conditions

Here is the first industrial infrared analyzer based on the proven principles of laboratory spectrometers and used for continuous monitoring and control of chemical processes. The Bichromator Analyzer is a two wave length, dispersion-type instrument, applying base-line density principles of the infrared laboratory to continuous process analysis.

It is an extremely stable and rugged instrument with no moving optical parts. The simple radiation null principle and closed loop servo system insure rapid response, virtual freedom from source or line current variation, or changes in amplifier linearity. This photometric system allows full-scale recorder operation with as little as 3% change in transmission.

The Bichromator Analyzer continuously measures the concentration of one component in an industrial sample. It is set on two wave length intervals; one, unique to the sample being analyzed (the component of interest), the other at a reference wave length where the sample does not absorb radiation. The energy difference at the two wave lengths is proportional to the concentration of the component of interest and can be converted to a measure of the concentration.

Thousands of laboratory infrared spectrometers now in use attest to the accuracy and stability inherent in the design of the dispersion instrument. Furthermore, the performance of the Bichromator Analyzer *can be predicted* from laboratory spectrometer data and tied to present laboratory control procedures.

Check these features

1 Sample cell in separately purgeable compartment outside main instrument for ease of checking without exposing instrument proper to plant atmosphere.

2 Built-in test circuit for rapid, simple instrument checks *in hazardous areas* without need for tools or test equipment.

3 Electronics system features unitized construction with functional subassemblies for simplified servicing.

4 Special by-pass liquid sampling cells designed to give fast response and eliminate sampling lag.

5 Handles unstable or corrosive gases and liquids.

6 Handles hot or cold samples.

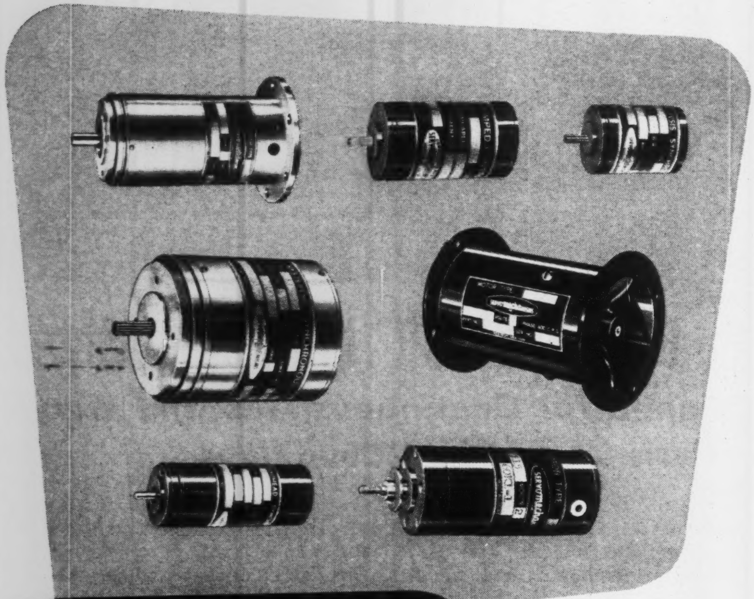
7 Interchangeable dispersion units, factory pre-set, for each specific control problem.

8 Field conversion to a new problem is possible.

Perkin-Elmer CORPORATION
Norwalk, Connecticut

For more information circle **134** on inquiry card.

New EXPANDED LINE OF
400 CYCLE INSTRUMENT MOTORS



Special designs to meet your requirements

This new line of miniaturized motors offers the designer a wide choice of frame sizes, speeds and input voltages resulting in versatility for multiple applications. High performance and high accuracy are incorporated in the design of all Servomechanisms motors manufactured to meet special and specific needs. Frame sizes are 1-1/16, 1-3/16, 1-7/16, 1-3/4, 1-15/16. Windings are available for 1, 2 or 3 phase with voltages to suit the applications.

Advanced design, quality materials and precision workmanship insure maximum performance and reliability.

- CONTROL MOTORS—WITH AND WITHOUT INTEGRAL DAMPING.
- HYSTERESIS SYNCHRONOUS MOTORS.
- INTEGRAL GEARHEAD MOTORS —ALL TYPES.
- GYRO MOTORS.
- BLOWER MOTORS.
- AXIAL FLOW BLOWERS.

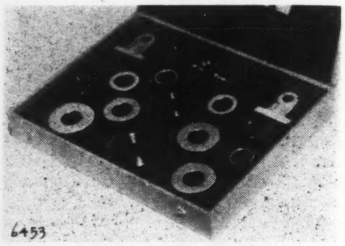
Write today for our new motor brochure.

SERVOMECHANISMS INC.

EB156

SERVOMECHANISMS, Inc. • Eastern Components Division • 625 Main Street • Westbury, L. I., N.Y.

For more information circle **135** on inquiry card.

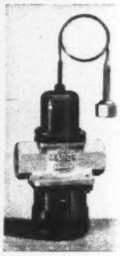

6453

end gears ranging from 63 to 160 teet in both aluminum and stainless steel also shaft hangers, Barden ball bea ings and set collars. Three basic unit immediately available: ¼″ shaft siz unit in 48 pitch, 3/16″ unit in 6 pitch and ⅛″ unit in 72 pitch.—*Pl Design Corp., 160 Atlantic Ave., Lyn brook, L. I., N. Y.*

For more information circle **469** on inquiry car

VALVES

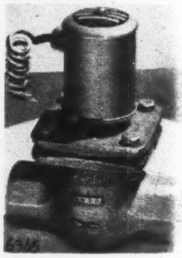
WATER-REGULATING VALVE



New "No. 56" is a pressure-actuated condensing water-regulating valve, designed with an exceptionally wide continuous adjustment range, 60 to 260 psi, permitting its use on either Freon 12 or Freon 22 systems as well as all other common refrigerants except ammonia. All adjustments can be made by hand.—*Jas. P. Marsh Corp.*, 3501 *West Hou ard St., Skokie, Ill.*

For more information circle **470** on inquiry car

SOLENOID VALVES

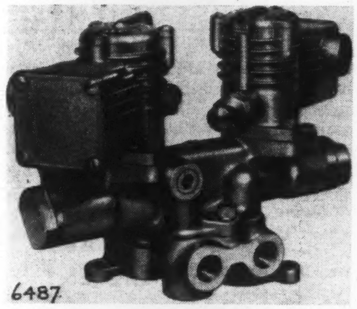

6305

New additions to maker's line of stainless-steel valves include N-O and N-C types in three sizes: 1¼″, 1½″ and 2″, all designed to eliminate hammer and shock in automatic or remote control of chemicals, steam, air, or gases. Features include renewable Teflon discs, full ports, uncond tionally guaranteed coils. Explosion proof coil housings, special assemblie and special alloys available.—*J. I Gould Co., 730 E. Washington St., In dianapolis 2, Ind.*

For more information circle **471** on inquiry car

FOUR-WAY VALVE

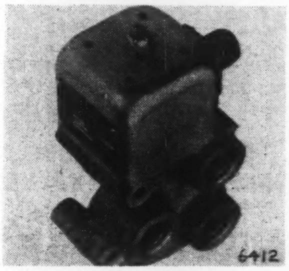
New double-solenoid "Speed King pilot-operated four-way valve, requi ing only momentary electrical conta for operation, can control up to 60 cycles per minute; is built to JI standards; is both moisture- and dus


6487

proof. Normal service life "conservatively estimated to be in excess of 20 million cycles." Available in ¼" to 1" pipe sizes, with foot or sub-base type mounting.—*Valvair Corp.*, 454 *Morgan Ave., Akron* 11, *Ohio.*
For more information circle **472** on inquiry card.

SOLENOID-OPERATED VALVES

New "Model 31" three-way solenoid-operated valves feature immediate availability of any size, style, etc., because all components are in stock for assembly and shipment within 24 hr after receipt of orders. Tube ¼" to ½". Among features: explosion-proof, ranges 0-5000 psi and −65°F to 275°F, flow rates up to 10 gpm.—*Mar Vista Engineering Co.*, 5420 *W.* 104*th St., Los Angeles* 45, *Calif.*
For more information circle **473** on inquiry card.


6412

FLEXIBLE VALVE

New "Superseal" full-pipe-capacity, completely-sealed metal-enclosed flexible valve, capable of operating under pressures as high as 250 psi, possesses all advantages of maker's regular "Flex Valve" while broadening fields of operation. Greater safety is assured by exclusive method of sealing all movable parts as well as valve body. Unique self-aligning drive pinches off sleeve body for positive tightness. Inner valve sleeve available in a choice of rubber and synthetic materials. "Flex Valves" are said to have out-

6359

ETALON INGAGE

measures the *exact* BORE

or blind hole size!

Reading: .0001"
Sizes: 3/16" to 1.6"

Takes accurate measurements of blind holes. No masters or setting rings—measures *directly*—by .0001".
Automatic alignment, rectangular contact points guarantee extreme accuracy even when fully extended. Immediately detects out of round holes; with extensions measures holes up to 6 feet deep. Hardened contact points exert only 11 oz. pressure—will not damage fragile work.
Easy to read, deep graduations on a large diameter thimble. Dull chrome plated. Furnished in English or Metric graduations, individually or in sets.

WRITE FOR CATALOG on complete line of precision measuring instruments:
VERNIER CALIPERS
MICROMETERS
DIAL INDICATORS

ALINA

ALINA CORPORATION
401 Broadway, New York 13

For more information circle **136** on inquiry card.

UNITED STATES RADIUM CORPORATION
serves you from

Sales Offices at:

EAST
535 Pearl Street
New York 7, N. Y.

MIDWEST
4624 W. Washington Blvd.
Chicago 44, Ill.

WEST
5420 Vineland Avenue
N. Hollywood, Calif.

CANADA
Radelin-Kirk, Ltd.
21 Dundas Square
Toronto, Can.

EUROPE
36 Chemin Krieg
Geneva, Switzerland

•

Plants and Laboratories at:
Bloomsburg, Pa.
Bernardsville, N. J.
Whippany, N. J.
North Hollywood, Calif.
Toronto, Canada

•

And now under construction—a new home office and plant at Morristown, N. J.

AS FEATURED AT THE IRE SHOW

RADIATION SOURCES
Gauging
Calibration
Ionization

EDGE-LIGHTED PANELS
Aircraft Control and Electronic Equipment

PLASTIC DIALS
Aircraft Instrument
Electronic Equipment

METAL DIALS, PANELS AND NAMEPLATES
ISOPTOPE ACTIVATED LIGHT SOURCES
LUMINESCENT MATERIALS
STATIC ELIMINATORS
TV PHOSPHORS
X-RAY SCREENS

U S RADIUM

For more information circle **137** on inquiry card.

YOU GET 3 BIG SAVINGS

WITH STANDARD R-S BUTTERFLY VALVES

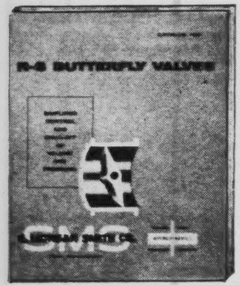
IN CATALOG 160

Based on 20 years' experience in process industry applications, R-S Butterfly Valves are now standardized. All components for those most commonly used, in sizes from 4″ to 48″, are carried in stock. By specifying standard R-S Valves, you now:

1. SAVE ON INITIAL DELIVERY – You can be sure of immediate service, because standard R-S Valves are ready for faster assembly and shipment.

2. SPEED REPLACEMENTS – Availability and faster delivery on standard R-S Valves can help you solve replacement problems and avoid costly, unscheduled shutdowns.

3. ELIMINATE ENGINEERING – In this new Catalog 160, you get the complete dimensions, layout drawings, specifications and materials for all pressure ratings of R-S Butterfly Valves that are now standardized. Data on operators and positioners is included. As new ratings are standardized, other sections will be published. To get a free copy and assure yourself of future sections, contact your SMS representative or write S. Morgan Smith Company, York, Penna.



HYDRAULIC TURBINES
PUMPS
GATES & HOISTS
TRASH RAKES
ACCESSORIES

HYDRODYNAMICS

ROTOVALVES
BALL VALVES
BUTTERFLY VALVES
FREE-DISCHARGE VALVES
CONTROLLABLE-PITCH SHIP PROPELLERS

SMS S. MORGAN SMITH

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED • TORONTO

For more information circle **138** on inquiry card.

worn metal valves 11 to 1 in abrasive-service tests. Available accessories include positioners, indicator stops, and specially designed "Superview" indicators for both manual and motor-operated types.—*Farris Flexible Valve Corp., 706 Commercial Ave., Palisades, N. J.*

For more information circle **474** on inquiry card.

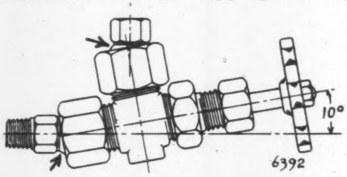
SS NEEDLE VALVES

New 416 stainless-steel needle valves designed for corrosive service and suitable for pressures up to 10,000 psi feature valve bodies and valve stem guides machined from solid 416 SS bar stock; valve stem hardened 416 SS precision machined with fine-pitch threads; deep chamber threads machined to extra-long length permitting even undersized pipe threads to make up tightly. —*Jas. P. Marsh Corp., 3501 W. Howard St., Skokie, Ill.*

For more information circle **475** on inquiry card.

SPHERICAL UNION CONNECTION FOR VALVES

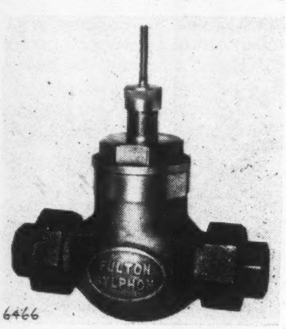
New spherical union connection for valves compensates for up to 10° misalignment of vessel tappings in any direction from perpendicular axis and a wide variation in centers; solves a multitude of installation problems.—*Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.*



For more information circle **476** on inquiry card.

VALVE FOR "DEAD ENDS"

New "Type MA" valve, said to fill "a need in industry for a tight-closing valve with good modulating characteristics," is particularly applicable on medium- and high-pressure pipe-

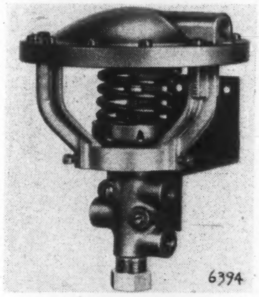


lines for difficult dead-end or complete shut-off service. Designed to avoid sticking and clogging, it does not develop a tendency to chatter or rattle. In tests on pipelines with pressures up to 250 psi, it functioned quietly. Sizes ¾" to 2".—*Robertshaw-Fulton Controls Co., Box 400, Knoxville, Tenn.*

For more information circle **477** on inquiry card.

SWITCHING VALVE

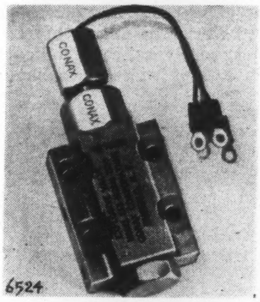
New "V-132" air-operated switching valve for use with dual-pressure pneumatic control systems is of exhausting 3-way type. It will switch automatically on a dual supply pressure change: no need for a separate air line from a central station; no need for a second pressure-electric switch and solenoid air valve.—*Johnson Service Co., Milwaukee 1, Wis.*



For more information circle **478** on inquiry card.

EXPLOSIVE VALVE

New "Conax Explosive Valve" operates instantaneously by firing a small completely-contained explosive squib. Normally-closed model is a dead-tight shut-off valve for storage of gas or liquid under high pressure. Flow passage is closed off by a diaphragm integral with valve body. Upon firing, an unobstructed flow passage from inlet to outlet ports (equivalent orifice 9/32" dia) is opened in 0.002 sec. Current required to fire squib is 0.5 amp. Smallest unit weighs 5 oz; is 1" hexagon by 3½" long; maximum operating pressure 5,000 psi, proof pressure 10,000 psi. Products of combustion are completely sealed in explosive chamber: no contamination of system.—*Explosive Products Div., Conax Corp., 7811 Sheridan Drive, Buffalo 21, N. Y.*



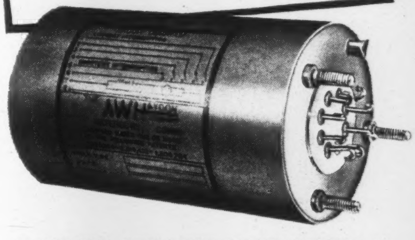
For more information circle **479** on inquiry card.

VETERAN PERFORMERS . . *preferred where performance is paramount* . . .

presented by THE **A.W. HAYDON CO.**

Miniature-Hermetically Sealed TIME DELAY RELAYS

6400, 11400, 24300 Series . . . AC, DC, 400 cycle.
Clutch-driven lever action. Time delay settings from 2 seconds to 3 hours. Where necessary, switching provided from 15-100% of overall interval.
Normal time settings within ± 10% of rating at rated voltage.
Short interval timings designed for 5600 or 5800 governed DC motors. Accuracy adjusted for 60 or 400 cycle synchronous motors, 5300 DC's, and chronometrically governed DC motors.
Repeating Accuracy specified ± 3% of overall interval.
Flexible design to meet all requirements, including multiple switches. Filtering provided for DC motors to meet MIL-I-6181 specifications.
Choice of Flange or Stud mounting.
Aluminum hermetic enclosures evacuated, flushed, and filled with dry Nitrogen. Glass seal headers or AN connectors. All military environmental specifications met.
Standard unit withstands vibration of 5-55 CPS at 10g maximum acceleration.



- 6400, 11400, 24300 SERIES DIRECT CURRENT, ALTERNATING CURRENT, 400 CYCLE. TIME DELAY SETTINGS FROM 2 SECONDS TO THREE HOURS
- SWITCHING FROM 15-100% OF OVERALL INTERVAL CAN BE SUPPLIED
- MEET MILITARY ENVIRONMENTAL SPECIFICATIONS
- FILTERING TO MEET MIL-I-6181B OPTIONAL ON DC UNITS
- WIRING DIAGRAM ON CASE

LENGTH "L" MAX.	6400 SERIES STANDARD D.C.	6400 SERIES GOVERNED D.C.	24300 SERIES 400 CYCLE A.C.	11400 SERIES 50,60 CYCLE A.C.
2 OR 3 SWITCHES	3 9/16	4 7/32	3 9/16	3 9/16

The **A.W. HAYDON** *Company*
Design and Manufacture of Electro-Mechanical Timing Devices

228 NORTH ELM STREET
WATERBURY 20,
CONNECTICUT

For more information circle **139** on inquiry card.

---

practical and accurate

for measuring oxygen or hydrogen present as impurities in other gases

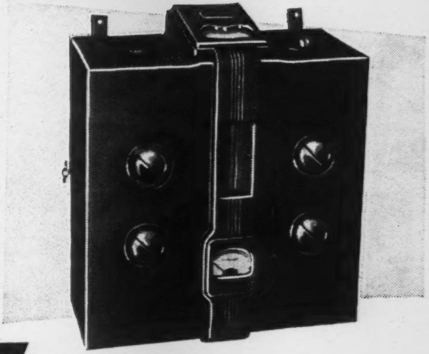
the durably constructed

DEOXO INDICATOR

The Deoxo Indicator permits a continuous and accurate reading of minute quantities of oxygen or hydrogen.

This equipment offers optimum efficiency within the range of .001% to 1.000% for oxygen and .002% to 2.000% for hydrogen.

A self-contained calibrating unit is included as an integral part of this unit. If desired, the Deoxo Indicator can be connected to controllers and recorders.



Write for additional data, technical assistance.

BAKER & COMPANY, INC. **PRECIOUS METALS**

113 ASTOR STREET
NEWARK 5, NEW JERSEY

ENGELHARD INDUSTRIES

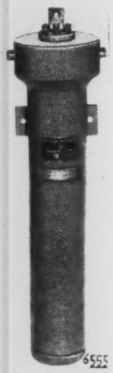
NEW YORK • SAN FRANCISCO • LOS ANGELES • CHICAGO

For more information circle **140** on inquiry card.

MISCELLANEOUS

AIR DRYER-CLEANER

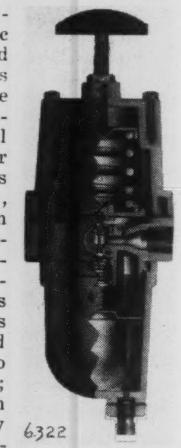
New "Models CM-15-3 and CM-25-6 Dehydrafilters" are especially applicable for test stand applications, jet aircraft and rocket research and other applications requiring clean, dry air or gas at high pressures. Capacities are 15 scfm @ 3000 psig and 25 scfm @ 6000 psig respectively, both at 70°F. Over-all height 23."—*Hankison Corp., 193 Biltmore Bldg., 951 Banksville Road, Pittsburgh 16, Pa.*



For more information circle **480** on inquiry card.

INSTRUMENT AIR REGULATOR

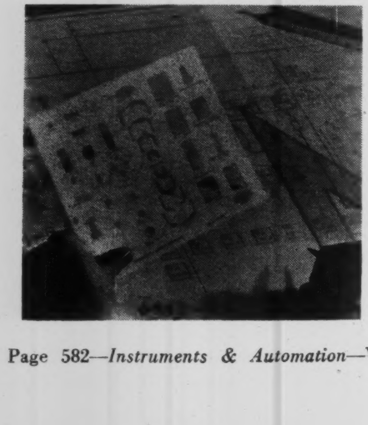
New "Type 73-26," for pneumatic instrumentation and in other installations requiring extreme sensitivity of pressure output in small volumes of air or other gas, features high air volumes, improved corrosion resistance, 40-micron phenolic-impregnated cellulose filter, instantaneous response to changes in flow rate, and easy adjustment to within close limits; it is available with or without auxiliary pressure gage. Maximum input pressure 3000 psig; maximum output pressure 40 psig (100 psig with special spring).—*Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Missouri.*



For more information circle **481** on inquiry card.

PANEL TEMPLATE

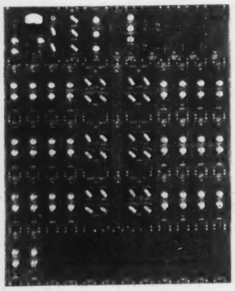
New "Panelgraph Layout Template" has scaled outlines representing the most frequently used industrial instruments, all scaled accurately at 2" to the foot; also outlines for pumps, valves and other graphic panel symbols as well as vessels. It can cut drafting time in half for a complicated graphic layout.—*Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Illinois.*



For more information circle **482** on inquiry card.

MULTI-USE SEISMOGRAPH

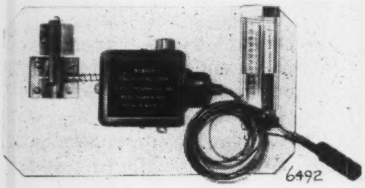
New "7000 B" seismograph system is designed for all types of seismic recording: high, conventional, or low frequency; reflection or refraction. It offers linear recording over exceptionally wide frequency range of 3 to 500 cps and is said to be "the most versatile seismic system yet developed," incorporating features of three systems. Playback at selected settings allows detailed examination of complete seismic spectrum.—*Houston Technical Labs., 2424 Branard, Houston 6, Texas.*



For more information circle **483** on inquiry card.

RIVET COOLER LOCK

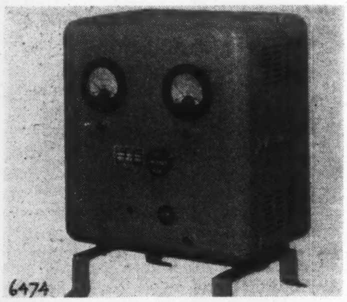
New temperature-controlled locking device aids in quality control of aluminum rivets by locking freezer door when temperature within cold chamber rises above pre-set level. (Aluminum rivets must be stored at −30°F after annealing to prevent splitting when pressure is applied.) Key is retained by supervisory personnel. New locking device has other applications because it can be pre-set to operate at any temperature from +20°F to −50°F. (Other models available with other ranges.)—*Webber Engineering Corp., Dept. LD-199, Box 217, Indianapolis 5, Indiana.*



For more information circle **484** on inquiry card.

GENERATOR CONTROLLERS

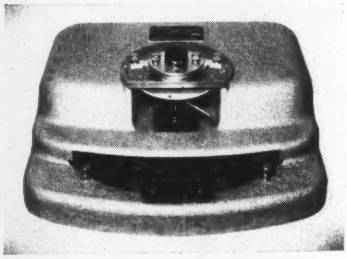
New "Packaged Generator Control Units" feature both automatic and manual voltage regulation; wall or generator mounting; ease of installation; any combination of two (illustrated) or three indicating instruments on panel.—*The Simplex Co., 1139 N. McArthur Blvd., Springfield, Ill.*



For more information circle **485** on inquiry card.

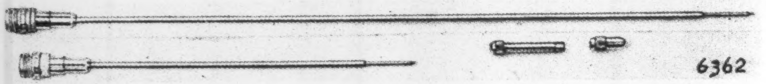
ELECTRICAL AND MECHANICAL ANGLE INDICATOR

New "Anglyzer" measures mechanical and electrical angles of resistors, switches, resolvers, etc.; indicates angles on a 360° scale on perimeter of



ANEMOMETER PROBES

New hot-wire anemometer probes are available in several standard styles (and specials to order) with tungsten or platinum-iridium wires of various standard diameters. Photo shows "Model HWP-B." Also announced is new "Model HWI Hot-wire Sum-difference Unit" for use (with "Model HWB" anemometer) to measure correlation between two velocity fluctuations at different points, or at the same place, in an air stream.—*Flow Corp., 283 Concord Ave., Cambridge 38, Mass.*



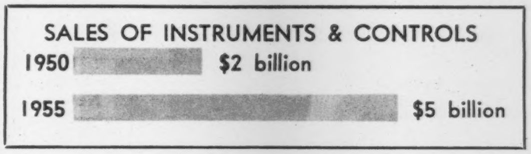
For more information circle **486** on inquiry card.

HELP YOURSELF TO A LARGER SHARE OF THIS GROWING MARKET

by *advertising* in the 1957 INSTRUMENTS & AUTOMATION HANDBOOK & BUYERS' GUIDE

(Formerly the I&A CATALOG & INDEX and the INSTRUMENT MANUFACTURING BUYERS' GUIDE)

SALES OF INSTRUMENTS & CONTROLS



Why dilute the effectiveness of your advertising in directories so general in scope as to eclipse the very market you are most interested in reaching?

INSTRUMENTS & AUTOMATION HANDBOOK & BUYERS' GUIDE is the *only* buying directory devoted *exclusively* to products and components in demand by this expanding instrumentation-automation market.

In the "Guide" pages of this annual directory, we list *your* products FREE . . . as a service to the buyers of instruments and automatic controls who use the directory through 12 months of product selection.

PAID DISPLAY ADVERTISING in this directory can help you compete *more effectually* for a larger share of the market by pinpointing valuable preselection data such as: product characteristics and specifications, special features, availability, etc.

Use your ad space in one or more of these ways to get results:

(1) Include your complete general catalog;

(2) Catalog your line on full pages, or

(3) Divide your space into fractional units placed near appropriate product headings.

Your FREE listings plus PAID advertising can provide the buyer with the essential data he requires to make a decision in favor of YOUR products. It saves both time and effort by minimizing correspondence.

Fill in the space reservation below and send it to INSTRUMENTS PUBLISHING CO., 845 Ridge Ave., Pittsburgh 12, Pa.; or contact any of our district offices.

DISTRIBUTION: 25,000 copies

PUBLICATION DATE:
October 1956

CLOSING DATES:
For Copy and Cuts: August 15, 1956
For Complete Plates: August 31, 1956

FORMAT:
Trim Size: 8¼ x 11¼ inches
Type Page 7 x 10 inches
Halftones: 110 screen

RATES:
$390 per page, or earned rate to I&A advertisers.

DISTRICT OFFICES:

oston—Andover 2212
Chicago—CEntral 6-8963
Dallas—PRospect 0189
etroit—TRinity 3-7480
os Angeles—SYcamore 7-2894 (Altadena)
New York—Murray Hill 8-0980
Philadelphia—Clearbrook 9-4342
Pittsburgh—FAirfax 1-0161
St. Louis—CHestnut 1-1965
San Francisco—DAvenport 5-4815 (Palo Alto)

ADVERTISING SPACE RESERVATION

Instruments Publishing Co.
845 Ridge Ave., Pittsburgh 12, Pa.

Date____________________

Please reserve total space amounting to ____ pages for our advertising in the 1957 INSTRUMENTS & AUTOMATION HANDBOOK & BUYERS' GUIDE.

We shall advertise the following products:

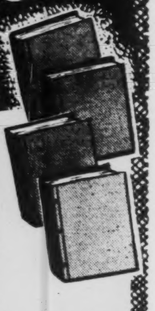
PRODUCT	AD DIMENSION
____________________	____" X____"
____________________	____" X____"
____________________	____" X____"
____________________	____" X____"

Company Name____________________

Address____________________

By____________________Title____________________

Newly Revised
ELECTRONIC
TEST EQUIP.
DATA
SHEETS



ENGINEERS

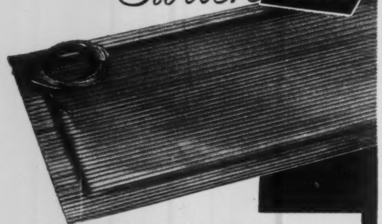
These DATA SHEETS will save your firm thousands of dollars in searching for data on ELECTRONICS TEST EQUIPMENT and give you comprehensive and descriptive data easily accessible for comparison. They are current and packed with vital working information Now available to industry for the first time.

- Order your copy of the 4 volume set containing illustrative data sheets on almost 1100 items procured for use by the U. S. Air Force.
- Contains over 3,000 (8½" x 11") pages, newly revised, mounted in 3 post expandable hard back binders.
- Price $135 per set plus tax & express charges while supply lasts. Express paid on orders accompanied by checks. *Free Sample Data Sheet with further details furnished on request.*

CARL L. FREDERICK AND ASSOCIATES
Bethesda 14, Maryland

For more information circle **141** on inquiry card.

RECORA
Switchmat



. . . thin, mat-like pressure switches that close circuits whenever pressure is applied to any point in their area; open circuits when pressure is released. Widely used as "area switches" on floors and platforms for automatic door openers, alarm systems, traffic controls etc. Used around machinery for foot switches, safety stations and emergency cut-outs. Available in any size, shape or quantity, for integral, built-in parts of mechanisms, devices and systems.

Operate at pressures from few ounces up, on low voltage, directly connected or through relays. Hermetically sealed between sheets of wear, acid and oil resistant vinyl plastic. Standard units, or to your specifications. Technical service supplied; just send us your switch problems.

Catalog Sheet CS-18 describing Recora Switches and control accessories sent upon request.

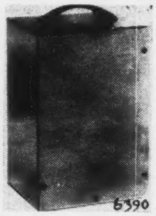
THE RECORA CO., INC.
6100 South Archer Road • Summit, Illinois

For more information circle **142** on inquiry card.

a disc that can be rotated with component in place. A vernier permits reading angles 0.1°. Component to be measured is quickly set up in full view and is readily accessible for attachment of associated equipment.—*Waters Manufacturing, Inc., P. O. Box 368, South Sudbury, Mass.*

For more information circle **487** on inquiry card.

CARRYING CASE

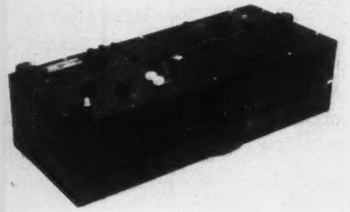


New portable carrying case is said to be light in weight yet extremely durable . . . ideal for housing oscillators, transceivers, test equipment, etc." Front and back panels easily removable. Various sizes available in 0.050" aluminum with etched finish and chrome-plated steel handle.—*Insuline Corp. of America, 186 Granite St., Manchester, N. H.*

For more information circle **488** on inquiry card.

MULTI-USE SEISMOGRAPH

New "Portable Blast and Vibration Seismograph," of three-component design, is said to be the first and only

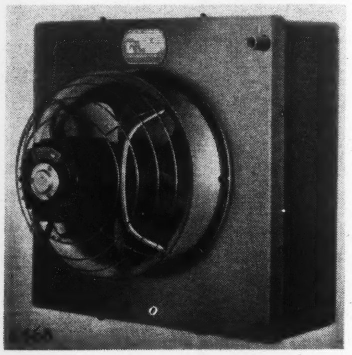


"complete tool" for recording vibrations caused by industrial operations: blasting, etc. It weighs 38 lb; requires no external connections; can be set up, leveled and made ready to operate in a few minutes. Its controls and adjustments are all accessible and plainly marked. All three components are recorded on a 2¾" strip chart with rectilinear co-ordinates. Any number of pre-loaded camera magazines can be used in sequence without requiring a darkroom. Chart speeds 50 to 100 mm/sec. All three recording light-spots are visible to operator just as they appear on record—making initial set-up easy and enabling operator to observe instrument's behavior while it records. Batteries: two size-D flashlight cells for recording lamp and timing lamp; two miniature 90-v. dry batteries for timing-circuit "B" voltage. Interpretation service: By engineering seismologist associated with St. Louis University.—*W. F. Sprengnether Instrument Co., 4567 Swan Ave., St. Louis 10, Mo.*

For more information circle **489** on inquiry card.

HEAT EXCHANGER

New 3-kw "Model A," for use in closed-system liquid circuits, finds application in transmitters, etc., incorporating liquid-cooled vacuum tubes.—*Rotron Mfg. Co., Schoonmaker Lane, Woodstock, N. Y.*



For more information circle **490** on inquiry card.

AUTOMATIC IRRIGATING SYSTEM

New automatic irrigating system assures adequate soil moisture content at root level of crop, whence water savings, better crop quality, and far greater yield. It measures percent

MICROWAVE TRAINING KIT

New "FXR Type X845A" kit includes complete microwave receiver, transmitter and an accessory group; also a specially-designed transit case; also fundamental text material for students and instructor's demonstration notes, as well as a student's laboratory exercise guide. By interchanging accessories, students learn fundamentals of propagation and effects and methods of shielding, polarization, reflection, focusing and bending of microwaves. Students learn microwave measurement techniques by taking numerical data.—*Electronics & X-Ray Div., F-R Machine Works, 26-12 Borough Pl., Woodside 77, N. Y.*

For more information circle **491** on inquiry card.

moisture at root level and determines when to actuate electric valves or when to start and stop pumping systems. Measurement method is the one employed in maker's soil testing equipment: porous block containing two electrodes buried at root level of crop.—*Industrial Instruments, Inc., edar Grove, N. J.*

or more information circle **492** on inquiry card.

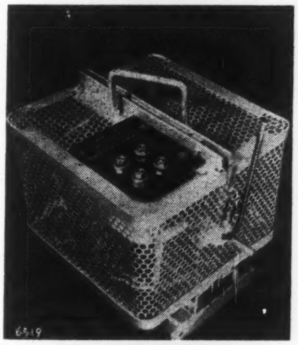
DIGITIZED WEIGHINGS

New digital-scanning electronic unit s said to be the first device to transmit weights to user's remotely located abulating card punches, adding mahines, etc. Thus it bridges gap beween weight indication by pointer eflection, and automatic numerical resentation of this weight at any emote location. Weights can be tabuated, added, recorded, or displayed n digital form. Digital conversion is chieved by an optical encoder "withut the electrical drift, non-linearity, f friction errors that were barriers o earlier efforts."—*Toledo Scale Co., oledo, Ohio.*

or more information circle **493** on inquiry card.

ELECTROMAGNETIC PUMP

New conduction-type electromagetic pump has no moving parts; is esigned to move liquid metals within

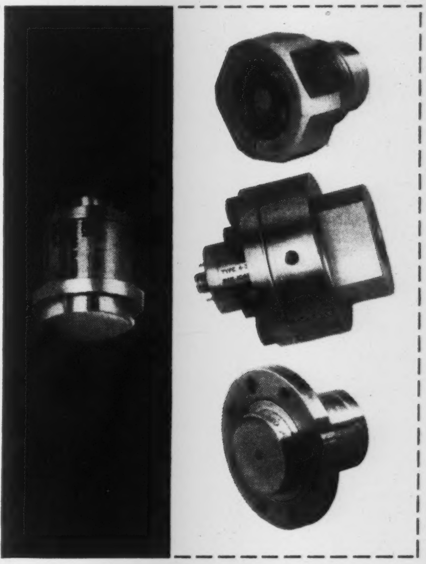


cooling or heating systems, to force iquid metals into forms in die-casting operations, etc. It will effectively pump fluid metals of lower electrical resistance than that of its pumping section's walls. It comprises (1) two urrent transformers, connected additively, supplying current to an armaure brazed to tubular pump section. Current path through armature is ontinuous across one flattened porion of pumping tube, through the ide of armature and across tube's ther flattened section. (2) For proucing magnetic field, four coils are laced one on each of the legs of wo U-shaped laminated magnetic ield cores. Flow rates are positively ontrolled by an adjustable autotransormer. Since pump is symmetrical, irection of flow can be reversed by eversing direction of magnetic field vith respect to direction of current hrough pumping section. It is possiole to do this even with the pump in operation.—*Callery Chemical Co., allery, Penna.*

or more information circle **494** on inquiry card.

Range . . . adaptability . . . compactness . . . accuracy. CEC's famous 4-300 Series of pressure pickups offers them all, plus an important extra: *Outstanding dependability*. They're accurate enough for the most critical laboratory work, rugged enough for rocket tests or monitoring well-drilling operations. For *any* pressure sensing job, whether it's for testing, monitoring, or control, look first at what CEC's 4-300 Pressure Pickups offer . . .

high
in a
rocket
or
deep
in a
well



for pressure measurements

think first of CEC pressure pickups

EXTREME MINIATURIZATION . . . bodies (shown above, actual size) as small as ½" in diameter.

ADAPTABILITY . . . several mounting methods offered as pictured above, right . . . standard fittings supplied.

WIDE CHOICE OF RANGES . . . gage, absolute, and differential units . . . full-scale ratings low as 1 psi, high as 5000 psi.

ACCURACY . . . 0.75% maximum linearity deviation . . . low hysteresis, temperature effects, and acceleration response.

STANDARDIZATION . . . same basic sensing element in all models . . . uniform excitation voltage and output greatly simplify system design and operation.

COMPLETE CALIBRATION CERTIFICATE . . . *all* characteristics measured . . . signed certificate sent with each pickup.

There's a CEC Pressure Pickup for almost every purpose. For complete information let us send you Bulletin CEC 1552-X42.

Consolidated Electrodynamics
CORPORATION
formerly Consolidated Engineering Corporation
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
300 No. Sierra Madre Villa, Pasadena, California
Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

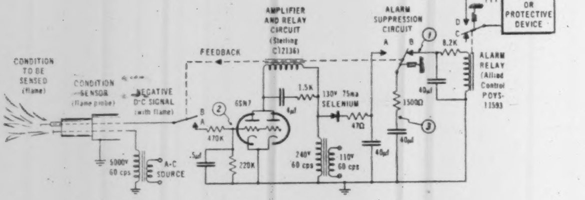
For more information circle **143** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Fail-Safe Control Systems

New technique for monitoring the output of any operating system is completely fail-safe . . . In essence, the monitoring system is subjected to a periodic checking signal which modulates the normal, or safe, operating condition.


CONDITION TO BE SENSED (flame)
CONDITION SENSOR (flame probe)
NEGATIVE D-C SIGNAL (with flame)
FEEDBACK
AMPLIFIER AND RELAY CIRCUIT (Sterling C12136)
ALARM SUPPRESSION CIRCUIT
ALARM OR PROTECTIVE DEVICE
ALARM RELAY (Allied Control POYS-11593
6SN7
470K
220K
.5µf
5000V 60 cps
A-C SOURCE
1.5K
4µf
130V 75ma SELENIUM
47Ω
240V 60 cps
110V 60 cps
40µf
1500Ω
8.2K
A
B
C
D
①
②
③

Failure of either system or variable halts the required oscillation and initiates corrective action.

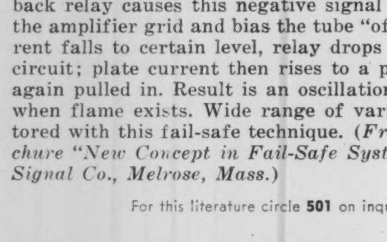
A fail-safe flame-monitoring system is shown. Feedback is employed to modulate the output of the condition sensor . . . The flame probe produces a negative signal. The feedback relay causes this negative signal to periodically bias the amplifier grid and bias the tube "off." When plate current falls to certain level, relay drops out and opens grid circuit; plate current then rises to a point where relay is again pulled in. Result is an oscillation that appears only when flame exists. Wide range of variables can be monitored with this fail-safe technique. (*From new 8-page brochure "New Concept in Fail-Safe System Design," Scully Signal Co., Melrose, Mass.*)

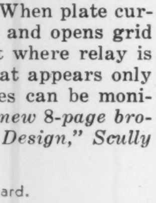
For this literature circle **501** on inquiry card.

All-gas Control System

The B-60 "All-Gas" Control System provides completely automatic control of gas-fired heating appliances without the use of *any* outside source of power. The system consists basically of the Pilot Generator, the B-60 Gas Control Valve and a thermostat or limit switch. The Pilot Generator (1) provides the flame for lighting the main burner, (2) is the source of the electrical energy for operating the Control System, (3) is the means of safety shut-off of gas in the event of pilot flame failure.

The Pilot Generator utilizes the principle of the thermocouple to produce the electrical energy required for the operation of the safety electromagnet. Since the current produced by an individual thermocouple is very small, it must be amplified before it can be used to operate a complete control system. The Generator accomplishes this by connecting several couples in series.


ARMATURE
ELECTROMAGNET
SPRING
VENT PORT
PRESSURE PORT
DIAPHRAGM
INLET
OUTLET
OPEN POSITION



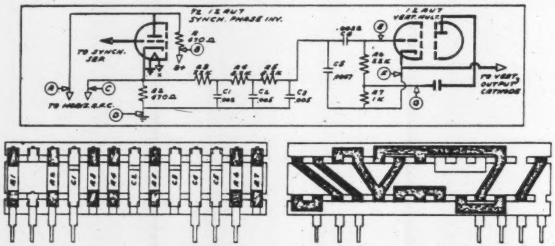
(500 Millivolts) Pilot Generator.

If the pilot flame becomes extinguished for any reason, the electrical current produced by the Pilot Generator ceases, and will not resume again until the pilot flame is relighted. As the B-60 Valve closes with current failure, this provides a positive automatic safety shut-off of the flow of fuel to the main gas burner. (*From 28-page B-60 Service Manual, General Controls Co., Glendale 1, Calif.*)

For this literature circle **502** on inquiry card.

PAC

The Erie Packaged Assembly Circuit "PAC" of modular assembly for electronic equipments is the result of an extensive research and development program . . . a practical and economical modular system of equipment assembly using either automatic or semi-automatic construction methods . . . It is based on uniform "building blocks" which are ⅛" in diameter and ⅝" long. All components used have these basic outline dimensions since they have been a standard for ceramic tubular capacitors and composition resistors for many years.


½ 12AU7 SYNCH. PHASE INV.
12AU7 VERT. MULT.
TO SYNCH. SEP.
TO HORIZ. A.F.C.
TO VERT. OUTPUT CATHODE
B+
A
B
C
D
E
F
G
P.A.C.- COMPONENT SIDE
P.A.C.-EMBOSSED WIRING SIDE

The PAC is designed primarily for use in conjunction with printed wiring chassis . . . the components for one or several stages are inserted in one "plugging-in" operation. If automatic insertion equipment is used, the number of insertion heads required is reduced greatly over other systems. Since this system uses individual components, better electrical characteristics and closer tolerances than the standard ceramic-based printed circuit are available. In addition, a greater number of components can be economically included in each "package." (*From new 14-page Engineering Bulletin 450-1, Erie Resistor Corp., Erie, Pa.*)

For this literature circle **503** on inquiry card.

Synchronous Drives

Recent experience has shown that Indox ceramic permanent magnets can be used efficiently in certain synchronous drives having an axial air gap.

Basic designs for efficient axial gap drive magnets made in Alnico and Indox are shown.

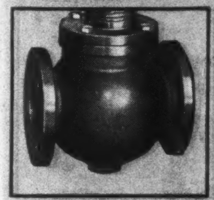
Indox, not being susceptible to demagnetizing like Alnico, did not require stabilizing test procedure. This means

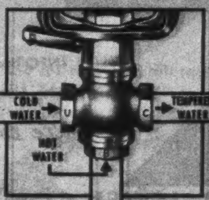
POWERS No. 11 Self-Operating TEMPERATURE REGULATOR

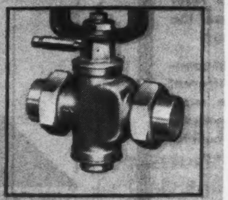
Automatically holds temperature constant at the right point. Prevents losses caused by wasteful OVER-heating.

POWERS
Has Overheat Protection
Easy to Install
Unsurpassed for Dependability
Single Seat Valve
POWERS CONTROL

Controls Flow of Steam, Water, Gas or Other Fluids




COLD WATER
U
C
TEMPERED WATER
HOT WATER

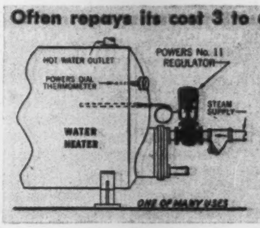


Various Valve Bodies and Inner Valves are available. Single and Double Seat Valves thru 2" have rugged bronze bodies with bronze union connections for quick, easy installation. Bulletin 329 gives information about all types. (c33)

For more information circle **144** on inquiry card.

Why It Gives
BETTER CONTROL
and Saves More Money

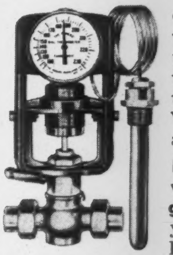
Often repays its cost 3 to 6 times a year when used on:


HOT WATER OUTLET
POWERS No. 11 REGULATOR
POWERS DIAL THERMOMETER
STEAM SUPPLY
WATER HEATER
ONE OF MANY USES

Water Heaters
Industrial Processes
Heat Exchangers
Fuel and Crude Oil Heaters
Air Compressors Diesel Engines

ONLY POWERS No. 11 REGULATOR
Offers ALL These Advantages

- **Simple, sturdy construction.** Materials used are corrosion resistant.
- **Powers bellows has 50% more power** than used in the majority of regulators. The heart of a self operating regulator is its bellows. Powers with its 50% greater effective area gives better control and its durable 2 ply bellows outlasts ordinary single ply bellows.
- **Valve stem lubricator** with silicone grease aids easy movement of highly polished stainless steel valve stem and reduces drying out of packing.
- **BETTER CONTROL** results from Powers powerful bellows and minimum of valve stem friction.
- **60°F. temperature ranges** available with accuracy of ±1°F. on some processes and 2 to 3°F. on others.
- **Rugged bronze valve bodies with bronze union connections,** for single and double seat valves thru 2", reduce installation time and labor. Larger sizes have flanged iron body valves.
- **Powers Nationwide Service and 24 Hour Delivery** in the U.S.A. are important time and money saving advantages.



- **Indicating Regulator** with easy to read 4" dial thermometer helps adjust the regulator and check temperature at the bulb. Various dials and ranges are available.

Right type and size of valve is important for good control. May we help you make the right selection? Benefit from POWERS more than 60 years experience with self-operating regulators.

Call our nearest office or write us direct for Bulletin 329.

THE POWERS REGULATOR CO.

Skokie, Ill. | Offices in Chief Cities in U.S.A.
Canada and Mexico | See your phone book

Automatic Temperature and Humidity Control
Established 1891

Wilmad

ELECTRONIC ENGINEERS!

FOR ECONOMY AND EFFICIENCY DESIGN WITH PRECISION GLASSWARE!

To keep costs down and yet get the maximum efficiency in electronic parts and sub-assemblies, more design engineers are turning to glassware.

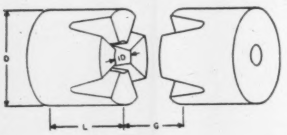
The reason is simple: the amazing tolerance limits, the low cost, and the unbelievable accuracy and uniformity of Wilmad precision glassware have made many metals, plastics and ceramics far too expensive.

If you design electric or electronic devices of any kind such as wave guide tubes, UHF tuners and cavities, voltage regulators, capacitors, dashpots, etc., investigate the economy and efficiency of precision glassware. Our engineers welcome the opportunity of discussing any of your design problems with you. Send for our new bulletin today.

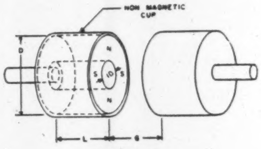
Wilmad
GLASS COMPANY, INC.
LANDISVILLE, N. J.

For more information circle **145** on inquiry card.

BRIEFS—CONTINUED



ALNICO

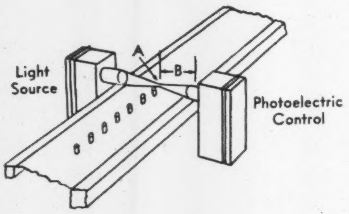


INDOX

that Indox magnets operated at small air gaps will still produce full torque at larger gaps, whereas Alnico magnets would require remagnetizing to obtain full torque after operation at smaller gaps. (*From 12-page issue, Vol. 3 No. 4, of "Applied Magnetics," Indiana Steel Products Co., Valparaiso, Ind.*)

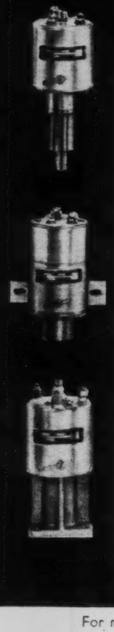
For this literature circle **504** on inquiry card.

Photoelectric Control



Application requirements of photoelectric controls: (1) Light beam should be interrupted 100%. (2) Light beam interruption and restoration periods should not be less than phototube dark time and light time specified. (3) Focused light beams are advantageous only when objects are

1-2 & 3 element
SPEED SENSITIVE SWITCHES



① Overspeed and Underspeed Governors are built to open or close a set of contacts when operating speed increases to dangerous proportions or when the speed drops to below normal running. Overspeed governors can be supplied to trip at any speed between 500 and 10,000 R.P.M. Underspeed governors at any speed between 400 and 5,000 R.P.M.

② Constructed to open or close two independent sets of contacts at adjustable speeds. Both switches trip on increasing speed and reset automatically on decreasing speed. Can also be furnished with a manual reset button, in which case it is necessary to reset the high speed switch after it has tripped.

③ Designed to open or close three independent sets of contacts at three different speeds. Particularly adaptable to the more elaborate engine and turbine control systems. Model shown is arranged for direct mounting on an AND 20005 engine tachometer pad.

These units are incased in dust and splash-proof housings.

SYNCHRO-START PRODUCTS
INCORPORATED
8151 N. RIDGEWAY AVE., SKOKIE, ILL.

For more information circle **146** on inquiry card.

JEWELS *for*
INDUSTRY. . .
By **MOSER JEWEL COMPANY,**
pioneer industrial jewel manufacturer for over 50 years.

- **HIGHLY POLISHED STEEL PIVOTS AND STAFFS**
- **HARD ALLOY WELDED TIPS**
- **NON-MAGNETIC STAFFS**
- **DIAMOND POINTS**

FOR INFORMATION ON HOW WE MAY FILL YOUR REQUIREMENTS

Write to . . .

MOSER JEWEL COMPANY
P.O. Box 150 • Perth Amboy, N. J.

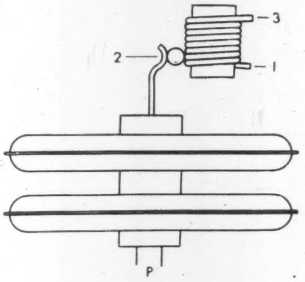
"Manufacturers of all types of Industrial Jewels"

For more information circle **147** on inquiry card.

too small to completely interrupt the beam. (4) Light intensity should not be less than the minimum specified. (4) Safety relays in the light sources can be arranged to stop a machine, close a valve, operate an alarm, or turn on an alternate filament in event of light source failure. (*From 16-page Catalog* 55, *Autotron Co., PO Box* 722, *Danville, Ill.*)

For this literature circle **505** on inquiry card.

Pressure Transducers



The pressure-responsive element is a diaphragm capsule the displacement of which, with change in pressure, moves the wiper of a potentiometer . . . . Currently available pressure transducers have tolerances within the following ranges: resolution 0.2 to 0.5%, linearity ±1.0% to ±1.5%, repeatability ±0.4 to ±1%, hysteresis 0.5% to 1% (higher on extremely high pressure ranges sensed with Bourdon tubes), temperature error 0.8 to ±1.5%.

Further development is dictated by demands that instruments operate at higher temperatures, at higher vibration levels, and under more severe mechanical shock. (*From new* 8-*page "Pressure Transducers Technical Note," Colvin Laboratories, E. Orange, N. J.*)

For this literature circle **506** on inquiry card.

REPUBLIC "LO-TORQ" SELECTOR VALVE

- **0-6000 psi service**
- **Low turning torque**
- **Panel mounting**
- **Semi-steel, bronze, aluminum alloy**
- **No leakage at any time**
- **3 types of portings**

Write for catalog No. 454 for complete information.
Distributors in principal cities from coast to coast.

RM
REPUBLIC MFG. CO.
CLEVELAND, O.

CHECK
RELIEF
PLUG
GLOBE
NEEDLE

132

RM

REPUBLIC MANUFACTURING CO.
15655 BROOKPARK ROAD • CLEVELAND 11, OHIO

For more information circle **148** on inquriy card.

✻ *Overload Protection*
✻ *Over and Under Voltage Protection*
✻ *Low Frequency Protection*

with field proven

G-V thermal sensing relays

G-V Sensing Relays operate contacts when current or voltage to their heaters exceeds or drops below the operating point. They can be selected with a response rate paralleling the action of the equipment. These relays operate quickly on heavy changes but tolerate slight changes until they become dangerous.

G-V
CONTACTS N.O.

Meets military requirements

Write for Engineering Assistance and complete technical Data. Ask for Publication 70.

G-V

G-V CONTROLS INC.
38 Hollywood Plaza, East Orange, N. J.

For more information circle **149** on inquiry card.

20
40
60
80
100
120
140
160
180
200

THE *Right* GAUGE FOR YOUR SPECIFIC NEEDS

MARSHALLTOWN

- Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

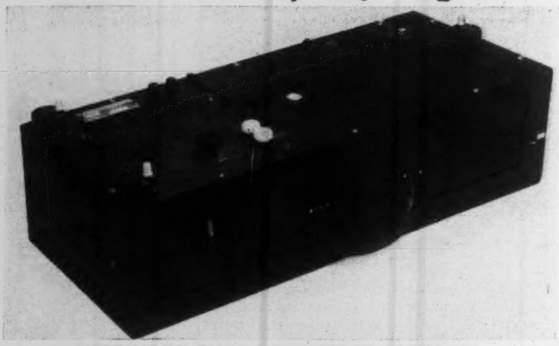
WRITE TODAY FOR COMPLETE INFORMATION.

PRESSURE, VACUUM, COMPOUND, ALTITUDE, COMBINATION, DIAPHRAGM, HYDRAULIC, AND SPECIAL PURPOSE GAUGES, DIAL THERMOMETERS, (VAPOR TENSION OR BI-METAL)

MARSHALLTOWN MFG. CO.
800 EAST NEVADA ST. • MARSHALLTOWN 3, IOWA

For more information circle **150** on inquiry card.

NEW! . . . Portable
BLAST and VIBRATION
SEISMOGRAPH
by Sprengnether



KEEP YOUR OWN PERMANENT RECORDS!

Features:
*Three Components
*Completely self-Contained
*Portable
*Transient or Steady-State Vibrations in the Seismic Frequency Range
*Rugged-Dependable
*Custom Designed to the User's Requirements

Entire instrument is self-contained in rigid aluminum case -25 x 10 x 8 inches Uses basic seismometer system. The three components are adjusted to 0.75 second. Timing lines are placed across record at 0.02 second. Instrument operates to give accurate record of displacement of ground as vibrations pass recording site.

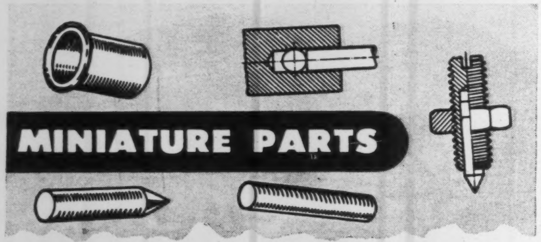
Interpretation service available by engineering seismologists associated with St. Louis University.

Send for Free Data Folder.

W. F. SPRENGNETHER INSTRUMENT CO. INC.

W. F.
SPRENGNETHER
INSTRUMENT CO., INC.,
4567 SWAN AVE., ST. LOUIS, MO.
Mfrs. of Seismological, Geophysical Instruments

For more information circle 151 on inquiry card.



CUSTOM MANUFACTURE of SMALL PARTS

Instrument Pivots
- As separate items or mounted in components—special steel, heat treated for maximum hardness, polished, metallographic finish. To specifications up to 3/8″ diameter.

Shafts and Staffs
- Burrless, plain or alloy steel, heat treated to specifications. Metallographic finish.
- Tubular Products up to 3/8″ Diameter, Cut, Flared, Swaged, Formed and Burr-Free. Alloy or Silver Plated.
- Screw-Machine Products up to 3/16″ Diameter.

SERVICES FOR CUSTOMERS' PARTS
- A Multitude of Services are Available for Customers' Parts at Any Stage of Manufacture. These Include: Controlled-Atmosphere Heat-Treating, Centerless Grinding, Surface Grinding, Special Facilities for Ceramic Rods and Shapes, Knurling, Thread-Rolling to close tolerances, Swaging, Drilling, Milling, Burr Removing, Metallographic Polishing, Barrel-Plating in Alloy or Silver, light Punch-Press Work.

SPECIALTIES
- "Welton" noncorrosive paste solder for hairsprings or similar soldering.
- "Wentonoil" treated bottonwood pith for lubricating instrument pivots.

APPARATUS DESIGN SERVICES
- In Connection with the Design and Fabrication of Precision Miniature Parts.

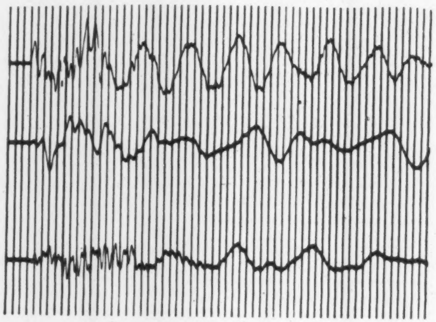
ENGINEERING ASSISTANCE ON ALL ITEMS

Welton V. Johnson
ENGINEERING COMPANY INC.
92 SUMMIT AVENUE • SUMMIT, N. J.

For more information circle 152 on inquiry card.

Portable Seismograph

The basic seismometer system consists of two inverted pendulums which respond to perpendicular components of the horizontal ground motion, and a spring-supported vertical pendulum for recording the vertical motion of the ground. All three components are adjusted to a natural period of 0.75 second.



Record of quarry blast

Motion of the ground, as detected by the seismometer system, is recorded photographically, with all three components appearing on a single strip of photographic paper 2¾ inches wide.

The ground motion is magnified by a mechanical-optical system by a factor of between 75 and 1000 . . . . Tim-

MERCOID®
CONTROLS

MERCOID CONTROLS
NO. 856
The Mercoid Corporation

NEW
CATALOG
NOW
AVAILABLE

WRITE FOR
YOUR COPY

ASK FOR
CATALOG No. 856P

THE MERCOID CORPORATION
4201 BELMONT AVE., CHICAGO 41, ILL.

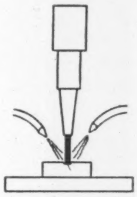
For more information circle 153 on inquiry card.

ing lines are placed across the record at intervals of 0.02 second by a specially designed oscillator and amplifier of great stability. The timing oscillator fires a glow modulator tube to form the timing lines on the record.

Since specialized knowledge is required for the interpretation of vibration records, the manufacturer has arranged for the analysis of records made with this equipment. Records sent back for computation will receive expert attention from engineering seismologists associated with St. Louis University. The records can be interpreted by the purchaser of the equipment if he should choose. (*From new 4-page brochure "Portable Blast and Vibration Seismograph." W. F. Sprengnether Co., Inc.*, 4567 *Swan Ave., St. Louis* 10, *Mo.*)

For this literature circle **507** on inquiry card.

Cavitation Machining



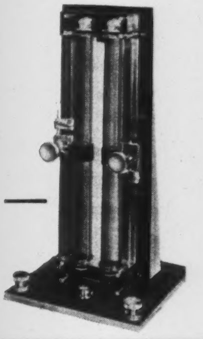
BOMBARDMENT

Abrasives in granular form do the work. The abrasive must be harder than the work piece and is closely graded to meet tolerance requirements. Typical abrasives are Boron Carbide, Silicon Carbide and Aluminum Oxide . . . Bombardment of the workpiece is by terrifically accelerated abrasive grains, which remove microscopic particles in exactly the right amount and places . . . Cavitation is produced within the liquid carrier of the abrasive, producing turbulence of the abrasive grains and constantly pres-

precise pressure measurement

Sensitivity 0.01%
(0.001 IN.)

NIL Type M-12 PRECISION MANOMETER



Write today for Bulletin 155
NATIONAL INSTRUMENT LABORATORIES
INC.

RANGES
9-0-11 INCHES
WATER OR MERCURY
Operable to 150 PSI

6108 RHODE ISLAND AVE., RIVERDALE, MD.

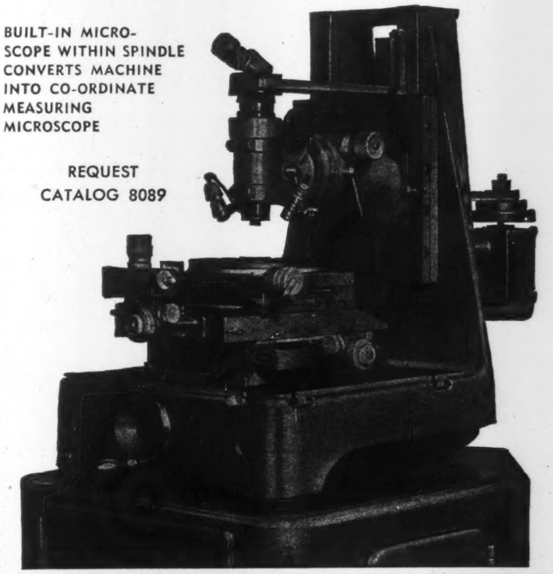
For more information circle **155** on inquiry card.

LEITZ OPTICAL JIG BORER

6" x 6" LINEAR CAPACITY FROM MASTER GLASS SCALES IN .00005"—8" CIRCULAR CAPACITY IN 10 SECONDS OF ARC—OBLIQUE HOLES UP TO 15 DEGREES FROM VERTICAL.

BUILT-IN MICROSCOPE WITHIN SPINDLE CONVERTS MACHINE INTO CO-ORDINATE MEASURING MICROSCOPE

REQUEST CATALOG 8089

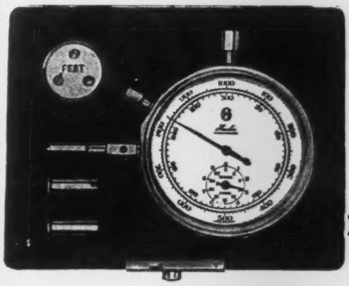


Geo. SCHERR OPTICAL TOOLS, Inc.
200-MG LAFAYETTE STREET • NEW YORK 12, N. Y.

For more information circle **154** on inquiry card.

HASLER SPEED INDICATOR

Chronometric Tachometer with separate reset button for cumulative readings



Accurate
Automatic
Durable
Flexible
Portable
Non-magnetic

Size
2¾" x ⅞" x 4"
Spindle incl.

Weight
7¾ oz.
ready for test

Type A	0-20,000	r.p.m.
or	0- 6,000	f.p.m.
Type B	0- 2,000	r.p.m.
or	0- 600	f.p.m.

Shipment within 5 days from stock

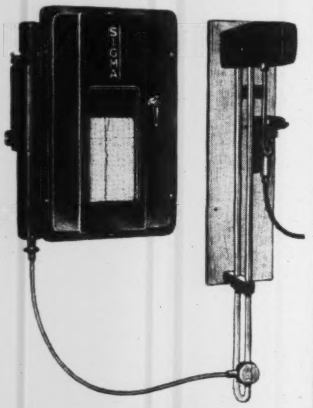
To order:
Type A-1 0-30,000 r.p.m.
All instruments serviced by

MEASURING REVOLUTIONS.

HASLER—TEL COMPANY,
28 Vesey Street, New York 7, N. Y.
U.S. Distributors for Hasler Speed Indicators since 1919

For more information circle **156** on inquiry card.

SIGMA
CALORIMETERS
Accurately RECORD calorific values of gases from 80 B.t.u.'s and up



- Provide reliable, trouble-free service
- Require little maintenance
- Simple in design
- Ruggedly built
- Free from continuously moving parts—except for chart drive
- Low in cost

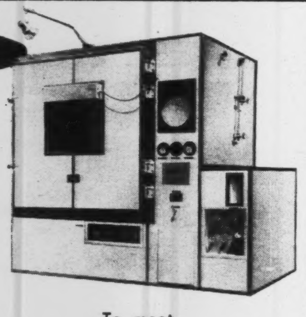
Write for Detailed Catalog

COSA CORPORATION
405 Lexington Ave., New York 17

NATIONAL REPRESENTATIVES FOR SIGMA INSTRUMENT CO., ENGLAND

For more information circle **157** on inquiry card.

DEVELCO



SALT
SPRAY
FOG
TEST
CHAMBER

To meet
MIL-E-5272
and others.

TOP OPENING
FRONT OPENING
WALK-IN

Write for Bulletin SS-55

DEVELCO

DEVELOPMENT ENGINEERING COMPANY

9 Cross Street • Norwalk, Connecticut

- *Manufacturers of Environmental Test Equipment*
Fungus Testing - Cold - Heat - Altitude - Humidity

For more information circle **158** on inquiry card.

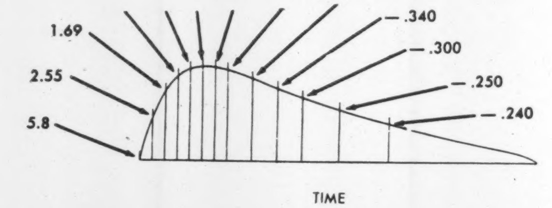
enting new cutting edges to the workpiece. The liquid further serves to flow additional abrasive to the cutting zone and wash away particles of workpiece material.

The hardest materials which are normally considered "unmachinable" are effectively shaped by this ultrasonic technique . . . Drawing dies in either solid or cored carbide inserts can be produced in complex shapes with finishes within 10 to 15 micro inches with average abrasives . . . Semi Conductors for transistor applications can be readily machined to precision standards. Germanium, Silicon, and other materials can be multiple shaped, sliced, or diced . . . Ceramics can be machined by ultrasonics with holes of odd shapes without chipping or shrinkage. Glass can be cut in complex shapes. (*From new 4-page brochure, L. C. Miller Co.,* 5005 *E. Dawson Ave., Los Angeles* 22, *Calif.*)

For this literature circle **508** on inquiry card.

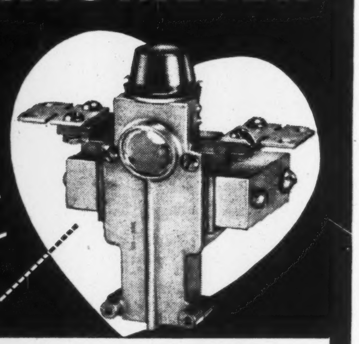
Derivimeter

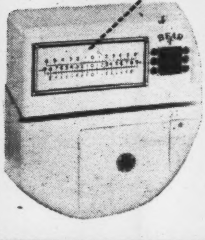
The Gerber Derivimeter is a simple mechanical desk computer designed to read the slope directly from a curve. It features a flexible metal strip forced at five points to assume the shape of the curve on which the derivative is to be taken. It reads the slope or the normal at any point



Make a G-M PORTABLE D'ARSONVAL
GALVANOMETER

the Heart of Your Instrument





IN THE AUTOMOTIVE FIELD, the Bear Manufacturing Co. of Rock Island, Ill. uses Series 500 G-M Galvanometers in its new remote-reading Electric Wheel Alignment System (left). Whatever your own particular instrument field, you can achieve this same self-contained portability, ruggedness and high sensitivity with G-M Galvanometers. Complete catalog on request.

G-M LABORATORIES • INC.
4316 NORTH KNOX AVE., CHICAGO 41

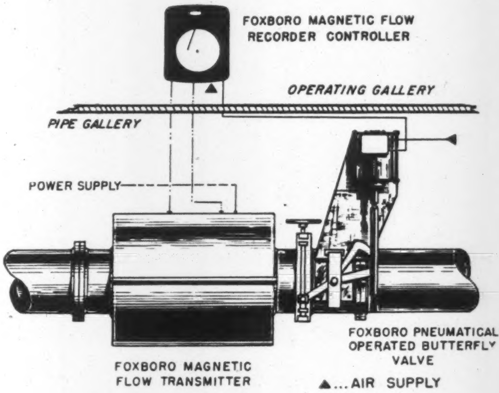
For more information circle **159** on inquiry card.

on a given curve. It is commonly used in the direct and precise graphical solutions of data where the rate of change of a plotted or recorded curve is required. (*From new 8-page brochure "The Gerber Derivimeter," The Gerber Scientific Instrument Co., 162 State St., Hartford 3, Conn.*

For this literature circle **509** on inquiry card.

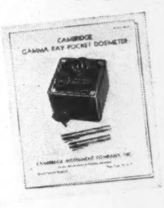
Magnetic Flowmeter Control

The engineer designing a water treatment system faces the problem of providing a control device on the filter effluent which will furnish both accurate flow measurement and minimum head loss. The Foxboro Magnetic Flow Meter solves this problem completely; head loss is no


FOXBORO MAGNETIC FLOW RECORDER CONTROLLER
OPERATING GALLERY
PIPE GALLERY
POWER SUPPLY
FOXBORO PNEUMATICALLY OPERATED BUTTERFLY VALVE
FOXBORO MAGNETIC FLOW TRANSMITTER
▲... AIR SUPPLY

CAMBRIDGE
GAMMA-RAY
POCKET
DOSIMETER

This personnel monitoring instrument measures the cumulative exposure to gamma or x-rays over a given period of time. The instrument consists of an ionization chamber, a quartz fibre electrometer and a graduated scale and viewing system. The charging unit comprises a 180 volt "B" battery, a 1½ volt "A" battery, a flashlight bulb, the well for inserting Dosimeter, and the charging control.



SEND FOR BULLETIN 300 G.D.

Other Cambridge Instruments for measuring radioactive emission are the Lindemann-Ryerson Electrometer, "Chang and Eng" Fast Neutron Detector and the Precision Ionization Meter (Failla Design).

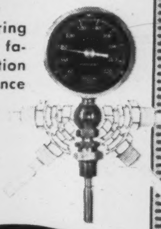
CAMBRIDGE INSTRUMENT COMPANY, INC.
3526 Grand Central Terminal, New York 17, N. Y.
PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS

For more information circle **160** on inquiry card.

YOUR GUARANTEE OF SATISFACTION

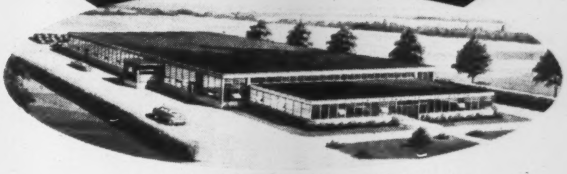
For 30 years, Weksler precision instruments have been preferred and specified by American industry and the Armed Forces, for temperature, pressure and humidity measurement.

Weksler's ultra-modern engineering and production techniques and facilities insure warranted satisfaction through construction, performance and service.



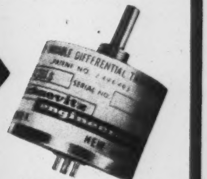
Write TODAY for your copy of the WEKSLER Condensed Bulletin of Instruments or see your local jobber.

WEKSLER
THERMOMETER CORPORATION
FREEPORT, L. I., N. Y.



For more information circle **161** on inqiuiry card.

For Continuous Measurement And Remote Indication of Angular Position



Use SCHAEVITZ
Rotary Variable
DIFFERENTIAL
TRANSFORMERS*

*Patented

The small, compact SCHAEVITZ RVDT produces a voltage whose magnitude varies linearly with change in the angular position of its shaft. It has complete electromagnetic shielding.

SCHAEVITZ RVDT'S are widely used in the continuous measurement and remote indication of angular position.

- primary excitation: up to 50 volts single phase ac in the medium audio frequency range of 400 cps to 20 kcps
- typical sensitivity: 9 millivolts/degree at 2000 cps with an input of 5 volts
- linearity: ± 1% over ± 40° and ± 3% over ± 60°
- input vs. output characteristic: symmetrical about the null point
- low operating torque: .014 in.-oz.
- low moment of inertia: 1.8 x 10^{-4} pound inch second^2
- the shaft, which is mounted on ball bearings, may be continuously rotated

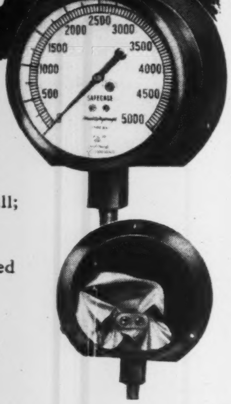
There is no rubbing or sliding friction of any kind in the SCHAEVITZ RVDT. Ask for further details.

schaevitz
engineering

P.O. BOX 505 • CAMDEN 1, NEW JERSEY
Merchantville 8-5353

For more information circle **162** on inquiry card.

New advance in...
GAUGE SAFETY



Another Marsh development... new "SAFE-CASE" gauge for those conditions where over-pressures of explosive force can occur.

Face well protected by solid metal wall; but, still more important, *entire back* is thin metal plate that opens out to exhaust any abnormal pressure. In testing, heavy blank cartridges, fired within back of case, did not even break crystal.

Use "Safecase" for your toughest services. It is standard in Marsh "Mastergauge"—the highest development in pressure gauges. Ask for facts.

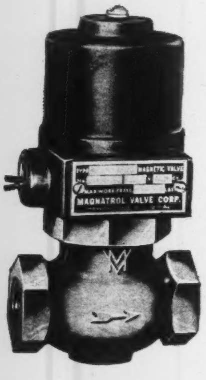
MARSH INSTRUMENT CO.,
Sales affiliate of Jas. P. Marsh Corp.
Dept. 42, Skokie, Ill.
HOUSTON BRANCH PLANT: 1122 Rothwell St. Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada

Test Proves Safety
Explosive force of cartridge merely opens out safety-release back. Back is firmly attached to case and cannot be dislodged during a pressure blow-out.

MARSH GAUGES

For more information circle **163** on inquiry card.

Eliminate
Costly Flow Failures



Magnatrol
SOLENOID VALVES

Quick Operating *Non Sticking* *Tight Seating*

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with **Magnatrol Valves.** Installed quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. **Every Magnatrol Valve** is delivered to you—factory **tested**—guaranteed free from defects in material and workmanship.

Available in normally closed or normally open models. Pressure ranges from zero up to 300 PSI. Voltages to 575.

Catalog containing complete specifications mailed upon request.

Magnatrol
VALVE Corp.
HAWTHORNE 14
NEW JERSEY

For more information circle **164** on inquiry card.

greater than in a straight section of pipe; accuracy is unaffected by the turbulence from upstream fittings; meter requires no pressure taps, no straight runs and the flow scale is linear.

There are only two requirements for the use of this meter: suitable conductivity in the fluid and a minimum flow velocity. In pipe sizes of 8" or over, a minimum conductivity of 50 micromhos is required. For sizes under 8", a somewhat greater conductivity is required. Usually, this is not a serious problem because most water supplies throughout the United States have conductivities well above these figures.

The minimum range is designed on the basis of five feet per second velocity at full scale and, since the scale is linear, the measurement is accurate and readable right down to zero. It is very effective as a detector of leaky valves in the line. There is no top limit on flow velocity. (*From 2-page Application Engineering Data Sheet* 831-32, *The Foxboro Co., Foxboro, Mass.*)

For this literature circle **510** on inquiry card.

Optical Tooling

Optical systems, consisting of alignment telescopes, optical squares and accessory instruments, have revolutionized the precision tooling for large aircraft structures. This accurate method of locating and aligning critical points and planes on assembly jigs and fixtures is capable of producing results superior to any mechanical method.

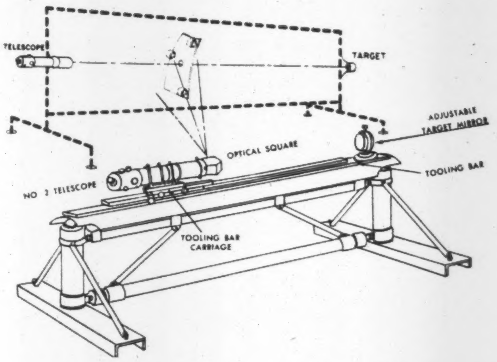
The basic and principal instrument in optical tooling systems is the Alignment Telescope with which you collimate, auto-collimate, auto-reflect or determine coincidence with built-in units . . . you obtain exact line of sight posi-

if it's a transformer problem KENYON is your answer!

Every day more and more engineers are looking to Kenyon for the answers to their transformer requirements. Whether standard or special applications, Kenyon stands ready to put its 32 years of transformer experience to work for you. The popular T Line, just one of Kenyon's standard products, incorporates uniformity and portability with economy. Write for catalog.

Kenyon Transformer Co., Inc., 840 Barry St., New York 59

For more information circle **165** on inquiry card.

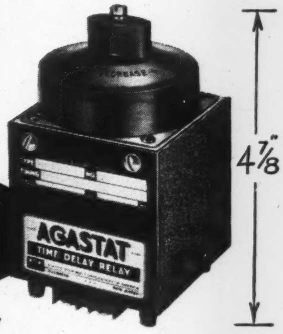


tioning with the integral standard spherical mount . . . you can use the telescope as a self-illuminated collimator. (*From new* 24-*page Bulletin* 808, *Farrand Optical Co., Inc., Bronx Blvd. and E.* 288 *St., New York* 70, *N. Y.*)

For this literature circle **511** on inquiry card.

Magnalux Tank Gage

As the level of the liquid in tank A changes, the level of the liquid in non-magnetic column B changes, since the two containers are connected by the pipe C. The float D follows this change. A magnet E is enclosed within float D. The field from this magnet, controls the motion and position of the steel or iron roller G. This roller contacts the common metal strip H and a resistance strip . . . the roller varies the amount of current that flows through the indicator circuit J and controls the position of the pointer K. Photoelectric cells can be mounted along the side of



Time delays in automation circuits

AGASTAT

Time / Delay / Relay

When automatic machinery and circuits must be timed with repetitive accuracy (from 0.1 second to ten minutes or more) you'll find a sure, reliable answer in AGASTAT electrically-actuated pneumatically-timed time delay relays.

The AGASTAT is
- light, versatile, dependable.
- unaffected by voltage variations.
- instantaneous recycling.
- available in models which offer delays on energizing and de-energizing, two-step delays, manually-actuated time delay switch, remote push button control.

WRITE **our application engineers for help with your timing problem. Address A23-39**

AGA DIVISION

Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing.

For more information circle **166** on inquiry card.

Write for this 56-page GUIDE to STACKPOLE ELECTRONIC COMPONENTS

STACKPOLE
ELECTRONIC COMPONENTS

FIXED RESISTORS
½, 1 and 2-watt types for every industrial and military use.

VARIABLE RESISTORS
Volume, tone controls, potentiometers, etc.

POWDERED IRON CORES

CERAMAG® Ferromagnetic CORES

MOLDED COIL FORMS

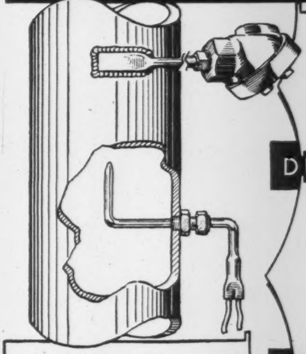
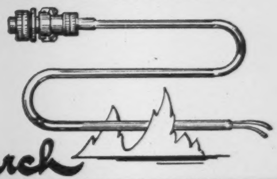
INEXPENSIVE SLIDE SWITCHES

GA CAPACITORS

CERATAB® PRINTED CIRCUITS

Electronic Components Division
STACKPOLE CARBON CO., *St. Marys, Pa.*

For more information circle **167** on inquiry card.

***SWAGED MGO FOR OPERATING TEMPERATURES −300 to 2000°F INSULATED THERMOCOUPLES**

SURFACE with STANDARD T/C Head
- Extremely accurate since junction can be welded to surface.

DESIGNING

IMMERSION with LEAD WIRE ADAPTOR
- Fast time response
- Install in any pipeline without a thermo-well by simply drilling and tapping.
- Pressure and vacuum tight.
- Variable immersion depth —easily replaced.

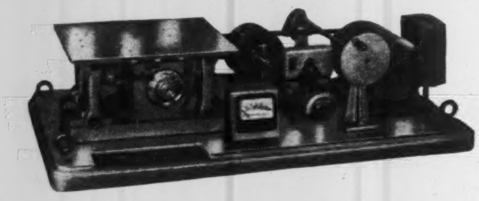
LEAD WIRE with QUICK DISCONNECT
- Available in long lengths or spliced together to meet your length requirements.

FABRICATING

*SWAGED MgO wire is available from our stock—Diam. .025 to 5/16". SEND FOR BULLETIN 4.

Aero Research
INSTRUMENT COMPANY, INC.
315 NO. ABERDEEN STREET, CHICAGO 7, ILLINOIS
Sales Representatives throughout the United States and Canada

For more information circle **168** on inquiry card.

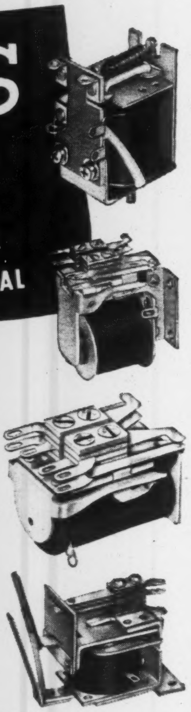


Range Selector Is Highlight Of All American Model 100 HLA-D Vibration Fatigue Test Machine

This machine subjects parts or assemblies, up to 100 lbs. in weight, to a comprehensive vibration fatigue test. It has a 50% overload safety factor. Vibration in simple harmonic motion is produced horizontally. Displacement (double amplitude) is adjustable from 0" to 125". Automatic Range Selector controls acceleration and deceleration. From 10 cycles per second frequency may be increased uniformly to 60 c.p.s. and then decreased to 10 c.p.s. Any desired range within the total may be selected. Selector can be switched off and frequency held at any c.p.s.

Recommended for testing electronic, electrical, mechanical or optical parts. One of 7 models. Send for Catalog F, containing helpful data, nomograph chart and listing typical users. Write to

ALL AMERICAN TOOL & MFG. CO.
8011 LAWNDALE AVENUE, SKOKIE, ILLINOIS
Makers of All American Precision Die Filing Machines.
For more information circle **169** on inquiry card.



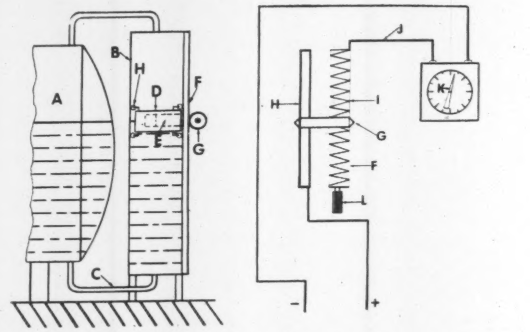
RELAYS
- FOR INDUSTRIAL USE
- FOR MILITARY USE
- SIMPLE OR COMPLEX
- STANDARD OR SPECIAL

Whatever your relay needs may be, Comar will design and "custom-manufacture" the right relay for you. Electrical characteristics, sizes and mountings are tailor-made to exactly fit your requirements. Precision-engineered, easier to install, more efficient in operation, economical in price. Send for details now!

Comar ELECTRIC COMPANY
3349 ADDISON STREET CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING
For more information circle **170** on inquiry card.

BRIEFS—CONTINUED

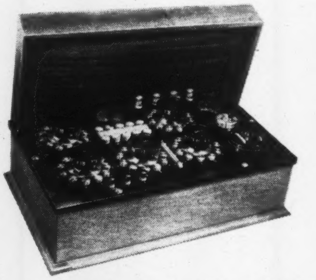


the roller raceway to actuate switches which can be used to control audible and visible alarms or solenoid valves or electric pumps. (*From* 4-*page Bulletin* 501, *Liquidvision Gauge & Control Corp., P.O. Box* 51, *Oceanside, L.I., N. Y.*)

For this literature circle **512** on inquiry card.

Readix Computer

The Readix is a general-purpose, digital, one-address, stored program computer of the medium speed class. It is available for either fixed point operation alone, or for fixed point and floating point operation . . . Each of the 4000 words of internal drum storage consists of 10 decimal digits and sign, or two commands, complete with addresses . . . Access time is 9 ms for working storage; 0.4 ms with optimum coding.



E-1002 MUELLER BRIDGE

The Mueller Bridge is designed for convenient and highly accurate measurement of platinum resistance thermometers in various temperature determinations. The high accuracy of this instrument is achieved by the use of very carefully adjusted and stabilized resistors used in its construction.

The same care is used in making the resistors for our:

POTENTIOMETERS
WHEATSTONE BRIDGES
KELVIN BRIDGES
RESISTANCE STANDARDS
RESISTANCE BOXES

Send for our catalog of laboratory and portable instruments

GRAY INSTRUMENT COMPANY
PHILADELPHIA 44, PA.

For more information circle **171** on inquiry card.

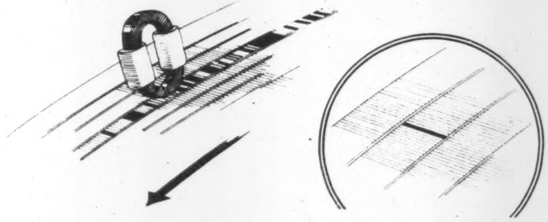
Internal operation is in the decimal number system, with each decimal digit represented by four binary bits. This "binary coded decimal" system simplifies the coding of most problems, and allows for scaling of quotients or products with a single shift order.

Commands: 5 Arithmetic commands; 8 Logical commands; 5 Modify Accumulator commands; 13 Transfer commands; 3 Channel commands; and 14 input-output commands. (*From new 12-page Brochure A-655, J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.*)

For this literature circle **513** on inquiry card.

Magnetic Storage Drums

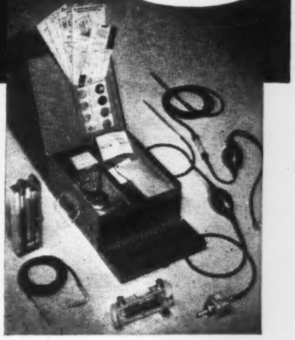
Information recorded on the drum is represented by combinations of magnetized spots or "bits." The polarity of each bit, North or South, determines whether a "0" or "1" is recorded—similar to the punched card technique of hole or no hole. The magnetized bits on the drum can be coded to receive alphabetic and numeric information from 80 or 90 column punched cards, punched tape (teletype code and others), magnetic tape, electric typewriter, numeric keyboard and other input devices.



A Complete Combustion Efficiency Test In 30 Seconds With the NEW, Low-Cost

DWYER COMBUSTION TEST KIT (No. 1100)

Dwyer CONTROLS GAGES



- SIMPLE TO USE
- LIFETIME ACCURACY
- PORTABLE
- COMPLETE
- INEXPENSIVE

Includes:

CO2 Indicator
Draft Gage*
Stack Thermometer
Smoke Gage
Slide Rule Computer
Magneclips
Instructions
...and all necessary accessories and fittings

Here's everything you need for a thorough, professional job of combustion testing. This new DWYER Kit simplifies the testing of any installation . . . residential, commercial or industrial: gas, oil or coal fired. You can perform a complete analysis in less than 30 seconds . . . *accurate to within ±½% CO2.*

Handy, handsome metal kit—(also available with CO2 Indicator alone)—is custom-fitted for all necessary parts and accessories.

*Draft Gage...famous DWYER Inclined Manometer. Continuously indicating type, permanently accurate—choice of ranges: 0 to ¼", 0 to ½", or 0 to 1" water.

Write for complete information

F. W. DWYER MFG. CO.

P. O. BOX 373-S • MICHIGAN CITY, INDIANA

For more information circle **172** on inquiry card.

WINZELER
Stamped Gears

Get Greater Accuracy In Your Stamped Gears

EACH WINZELER STAMPED GEAR, in runs of hundreds or *thousands*, equals or surpasses the most exacting specifications. They invariably cut assembly time, and costs. Mechanisms run smoother, sweeter, longer. And users like the quiet, dependable performance of WINZELER Geared products. Send along drawings, specifications, quantities needed. Let our capable staff help you.

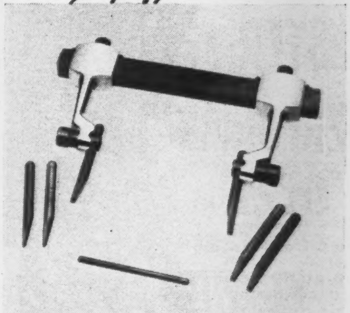
SEND FOR *useful 4-page folder . . a valuable Stamped Gear guide. Gives technical data, tables, ideas, suggestions, descriptions of many types. Use company stationery please!*

WINZELER MANUFACTURING & TOOL CO.
1712 WEST ARCADE PLACE, CHICAGO 12, ILLINOIS

For more information circle **173** on inquiry card.

Eliminate makeshift or expensive special jigs with the

ROLYN *Adjustable* **Key Spanner**



An indispensable tool for Scientific Instrument Makers, Repairmen, Engineers, Electricians, Wireless Mechanics, Motor Engineers

Now you only need *one* tool for removing or securing Internal or External Locking Rings • Bushings • Collets • Thrust Collars • Internal Cells, countless other adjustments.

The Key Spanner is easily adjustable for diameter and depth giving a positively rigid action up to a maximum capacity of 3" diameter.

Saves its cost in time saved and damage avoided.

PRICE POSTPAID
$27.90
(Includes 3 sets of keys)

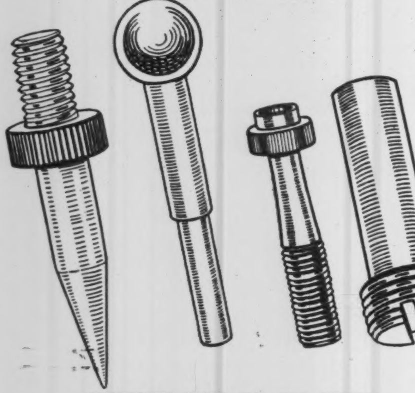
Robert M. Lynn
OPTICAL • GLASS • PHOTO
(ROLYN COMPANY)
Established 1923
319 No. Santa Anita Ave. • Arcadia, California

Cable Address
"Rolyn" Los Angeles
DOuglas 7-3200

Address reply to
Post Office Box 745
Arcadia, California

For more information circle **174** on inquiry card.

Serving
Instrument Manufacturers
with **AUTOMATIC**
SCREW MACHINE PARTS
ALL SECONDARY OPERATIONS
Drilling-Tapping-Milling-Cylindrical and Centerless Grinding
Heat Treating and Plating



CUTTING DIES OF ALL KINDS
Machine Shop Work — Jigs and Fixtures
PROGRESSIVE SERVICE CO.

Main Office & Factory
2743 Locust St.
St. Louis, Mo.
Tel. Jefferson 1-4300

Branch Office & Factory
80 S. Cameron St.
Harrisburg, Pa.
Tel. Cedar 6-9329

38 Years Experience

For more information circle **175** on inquiry card.

KESTER SOLDERFORMS®
BIG STEP in
Production Cost-Cutting!

Take a giant step forward in lowering assembly costs with Kester Solderforms. Labor costs are reduced, assembly operations speeded up. There's no solder waste, and the end result is a neater, more expertly finished product.

WRITE TODAY for complete Kester Solderforms information. Free!
KESTER SOLDER COMPANY
4270 Wrightwood Ave.
Chicago 39, Illinois
Newark 5, New Jersey
Brantford, Canada

For more information circle **176** on inquiry card.

BRIEFS—CONTINUED

If you need large storage capacity, there is a standard ERA drum that can hold 2,552,000 bits or one-half million alphanumeric characters. On the other hand, if speed is more important in your application, certain standard drums in the ERA line can write or read at any chosen spot on the drum in less than five milliseconds (see table).

Storage Drums	Type 1119	Type 1100	Type 1110
Max. RZ Bit Capacity	128,400	470,400	2,552,000
Max. No. Tracks	120	224	464
RZ Bits/Track (approx.)	1070	2100	5500
Max. Access Time (millesec)	Variable 11.3-4.5	17	51

ERA Types 202 and 205 Heads feature ferrite cores, pulse density (RZ bits/inch) of 80, track density (tracks/inch) of 16. (*From 4-page Bulletin PX-71843, Remington Rand, Inc., Engineering Research Associates, Div.,* 1902 *West Minnehaha Avenue, Saint Paul W4, Minn.*

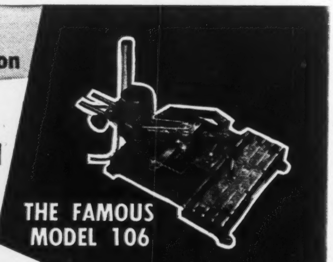
For this literature circle **514** on inquiry card.

Aircraft Temperatures and Pressures

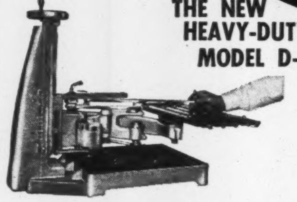
Specialization is essential to the design of aircraft engines. Harco Laboratories was organized expressly to design and fabricate temperature and pressure sensing instruments for the aircraft industry—thermocouples, harnesses, extension leads, connectors, and pressure probes.

In all electrical circuits the connectors are under constant suspicion . . . in a thermocouple circuit it is possible

unique in design — rugged in construction
GREEN PANTOGRAPH ENGRAVERS



THE FAMOUS MODEL 106



THE NEW HEAVY-DUTY MODEL D-2

The three-dimensional bench Model 106 cuts costs — engraves, routs, models and profiles, giving you expert results even by unskilled workers.

The Model D-2 two dimensional heavy-duty Pantograph is a precision machine with a multitude of new features. Open on three sides, it permits complete freedom for engraving, milling, profiling large panels (up to 30" in diameter) or bulky pieces. Single, micrometer adjustment controls vertical depth of cut, automatically adjusting copy table with pantograph. Range of reduction ratios from 2-to-1 to infinity! Vertical range over 10 inches!

For complete information, write to

GREEN INSTRUMENT COMPANY
383 Putnam Ave. Cambridge, Mass.

For more information circle **177** on inquiry card.

Chromel-Alumel Thermocouples

(Electromotive Force in Absolute Millivolts. Temp. in Degrees F.*

°F	0	1	2	3	4	5	6	7
					Millivolts			
−300	−5. 51	−5. 52	−5. 53	−5. 84	−5. 54	−5. 55	−5. 56	−5. 5
−290	−5. 41	−5. 42	−5. 43	−5. 44	−5. 45	−5. 46	−5. 47	−5. 4
−280	−5. 30	−5. 31	−5. 32	−5. 34	−5. 35	−5. 36	−5. 37	−5. 3
−270	−5. 20	−5. 21	−5. 22	−5. 23	−5. 24	−5. 25	−5. 26	−5. 2

Centigrade-Fahrenheit Conversion Table

C.	←F. ↓ C.→	F.	C.	←F. ↓ C.→	F.	C.	←F. ↓ C.→	F.
-62.2	—80	—112.0	32.2	90	194.0	112.8	235	455.0
-56.7	—70	— 94.0	35.0	95	203.0	115.6	240	464.0
-51.1	—60	— 76.0	37.8	100	212.0	118.3	245	473.0
-45.6	—50	— 58.0	40.6	105	221.0	121.1	250	482.0
-40.0	—40	— 40.0	43.3	110	230.0	126.7	260	500.0
-34.4	—30	— 22.0	46.1	115	239.0	132.2	270	518.0

or a connector to introduce an error without any obvious arning . . . Impressive connector errors can appear be- ause of surface corrosion which can convert the contact air into an electrical cell or a rectifier or a varistor. The esigner must know the extent to which the system must esist moisture and corrosion; existing temperature grad- ents; mechanical requirements; the possibility of alter- ating voltages either due to induction from nearly a-c ircuits or to a-c generation in the tc circuit itself due to ibration in a magnetic field. The last condition is much ommoner than suspected; the a-c voltage is readily recti- ied at any unsound connection and then becomes a d-c rror signal. (*From new 32-page brochure "Sensing De- ices," Harco Laboratories, Inc., New Haven, Conn., which ncludes seven pages of tables for temperature conversion nd tc emf.*)

For this literature circle **515** on inquiry card.

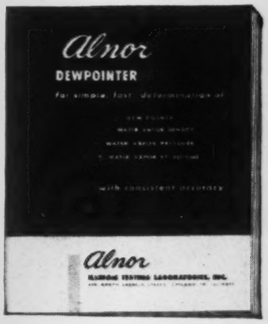
get this

free

INFORMATIVE BULLETIN

Learn how easy it is for anyone to determine dew points quickly and accurately with the

ALNOR DEWPOINTER!



Only the Alnor Dewpointer has a sealed testing chamber, where atmospheres can be analyzed under controlled conditions . . . where the fog is observed *suspended in air* for fast, positive readings. Completely self-contained and readily portable for laboratory accuracy anywhere in the plant or field. And simple, direct operation enables even nontechnical personnel to easily obtain precise results, time after time.

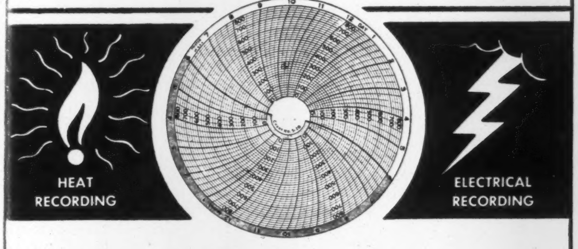
Tear out this ad and send it along with your business letterhead to Illinois Testing Laboratories, Room 518, 420 N. LaSalle St., Chicago 10, Ill.

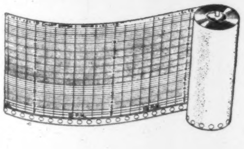
Alnor

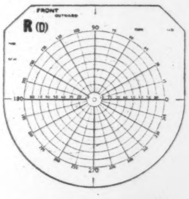
PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **178** on inquiry card.

CHARTS of all types







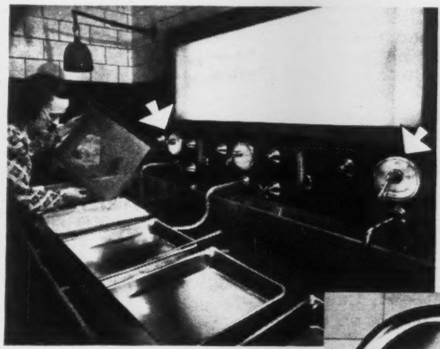
Over 40 years' experience in serving the Instrument Industry.

Charts for Ink, Electrical, Heat and Stylus recording. Special time numbering and perforations to meet widely varied specifications.

Can we help you meet your specific requirements?

GUBELMAN *Recording* CHARTS
GUARANTEED ACCURACY

GUBELMAN PUBLISHING COMPANY
100-106 EAST KINNEY ST. NEWARK 5, N. J.



Some of the More than 25 POWERS Thermostatic WATER MIXERS in the Milwaukee JOURNAL'S Famous Color Film Processing Laboratory

WARMER
POWERS

Perhaps POWERS has the Right answer for your water temperature control problems. Whether you want ½° F. plus or minus control for any type of film processing, camera lens polishing or thermostatic control for jacket water cooling in a 3500 hp diesel engine or a cyclotron—contact POWERS. No other firm has such a complete line of water temperature controls. Bulletin 367 covers control for film processing.

(b55)

THE POWERS REGULATOR CO., SKOKIE, ILL.
Offices in over 50 Cities, see your Phone Book • Established in 1891

For more information circle **179** on inquiry card.

INSTRUMENTS and AUTOMATION

New Literature

AUTOMATION

Nullmatic Transmitter-Controllers. New 36-page Bulletin AD68 presents 50 basic process applications using maker's "Nullmatic" multi-function remote controllers.—Moore Products Co., H & Lycoming Sts., Philadelphia 24, Pa.

Circle **516** on inquiry card.

Annunciator Systems. New 26-page catalog describes maker's complete line of annunciator alarms and process monitors.—Scam Instrument Corp., 3855 N. Kedzie, Chicago 18, Ill.

Circle **517** on inquiry card.

Sewage Plant Instrumentation. New 12-page illustrated Bulletin 90-242-11 describes instrumentation for sewage treatment plants.—Fischer & Porter Co., Hatboro, Pa.

Circle **518** on inquiry card.

Magnetic Amplifier Control. New 6-page booklet B-6584 describes "Cypak" logic function control device that features no moving parts.—Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.

Circle **519** on inquiry card.

VALVES

Needle Valves. New 24-page catalog presents maker's line of high-pressure, corrosive-resistant valves and fittings.—Dragon Engineering Co., Los Angeles 11, Calif.

Circle **520** on inquiry card.

Solenoid Valves. New 4-page brochure describes line of stainless-steel pilot-operated solenoid valves for use where corrosion resistant materials are required.—J.D. Gould Co., 730 East Washington Street, Indianapolis 2, Indiana.

Circle **521** on inquiry card.

Valves, Fittings. New 24-page Catalog No. 2055 presents specifications on maker's line of valves, fittings and tubing.—High Pressure Equipment Co., Inc., 1222 Linden Ave., Erie, Pa.

Circle **522** on inquiry card.

Tungsten Carbide Valve Trim. New 8-page catalog and price list presents oil and gas flow control equipment featuring "Stonebor" trim.—Stone Instrument and Supply Co., 315 Erin St., Houston, Texas.

Circle **523** on inquiry card.

Check Valve. New 4-page brochure describes maker's seatless check valve for gas, air and other fluid lines.—Techno Corp., 16 West 5th St., Erie, Pa.

Circle **524** on inquiry card.

Valve Union Connection. New 2-page Data Sheet 278 describes and illustrates uses of maker's union connection for use on maker's valves.—Jerguson Gage & Valve Co., 87 Fellsway, Somerville 45, Mass.

Circle **525** on inquiry card.

Quick-Connect Vacuum Valves. New 2-page bulletin describes maker's "Model 4300" quick-connect vacuum valves with leak rate less than 0.1 micron cu ft per hr.—Naresco Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass.

Circle **526** on inquiry card.

Hydraulic Test Stand. New 2-page Bulletin C-55-1 describes maker's "Model 2632" hydraulic test stand for testing valves, cylinders, regulators, etc. to 5000 psi. Includes 2-page engineering data sheet.—Auto-Control Laboratories, 5665 Selmaraine Drive, Culver City, Calif.

Circle **527** on inquiry card.

MOTORS,

Timing Motors. New 2-page Bulletin MO 800 describes accuracy and power of maker's chronometrically governed d-c timing motors.—A.W. Haydon Co., Waterbury, Conn.

Circle **528** on inquiry card.

Step Motors. New 2-page Bulletin SM 306 describes direct-current devices that follow a transmitter without need for feedback.—Gap Instrument Corp., 253 West Merrick Road, Valley Stream, L. I., N.Y.

Circle **529** on inquiry card.

Speed Control. New 8-page issue of "The Experimenter" (Vol. 30 No. 8) features new models of the maker's "Variac" speed controls with dynamic braking.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **530** on inquiry card.

Compound Motor Drives. New descriptive sheet by maker features their compound belt drives with handwheel or yolk control.—Lovejoy Flexible Coupling Co., 4949 W. Lake St., Chicago 44, Ill.

Circle **531** on inquiry card.

Motor Load Indicator. New 2-page Bulletin MLI-2.1 presents maker's indicator for motor loads, calibrated in % load.—Machinery Electrification, Inc. Northboro, Mass.

Circle **532** on inquiry card.

TEMPERATURE

Temperature Controller. New 2 pages (No. 7 and 8) of maker's catalog describes temperature controller that translates variations of temperature directly to control flow (of fuel or heating or cooling medium) through diaphragm-operated valves. Also described is a safety shut-off pilot for use only with normally closed (diaphragm pressure open) valves.—Black, Sivalls & Bryson, Inc., Tulsa 1, Oklahoma.

Circle **533** on inquiry card.

Bimetallic Thermometers. New 4-page Bulletin 98267 presents design features and specs on 3" and 5" dial thermometers.—Taylor Instrument Cos., Rochester 1, N.Y.

Circle **534** on inquiry card.

PRESSURE, WEIGHT

Instrument Air Regulator. New 2-pages (Nos. 29 and 30) of maker's catalog describes instrument air supply regulator for pneumatic instrumentation or other installations requiring extreme sensitivity of pressure output.—Climax Controls, Black, Sivalls & Bryson, Inc., Tulsa 1, Oklahoma.

Circle **535** on inquiry card.

Pressure Transducers. Four new 2-page brochures present features and specs of maker's strain-gage-type transducers. Bulletin MPT-134 is on diff-press transducers; Bulletins G1 and G7A are on force or displacement transducers; Bulletin P60 is on pressure transducers.—Statham Laboratories, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle **536** on inquiry card.

Bridge Amplifier for Pressure, Strain Transducers. New 2-page Bulletin 6 describes bridge amplifier and meter for both dynamic and static work with resistance-type transducers for pressure, vibration, etc.—Ellis Associates, Box 77, Pelham, N. Y.

Circle **537** on inquiry card.

Heavy-duty Bulk Scales. New 6-page Bulletin 8946A pictures and describes three models of maker's "Class 38" automatic weighing unit for bulk materials.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **538** on inquiry card.

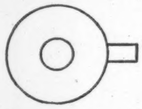
Mechanical Force Gage. New 4-page booklet illustrates imported gages for measuring relay contact pressures.—Guardian Electric, 1621 W. Walnut St., Chicago 12, Ill.

Circle **539** on inquiry card.

Vacuum Control. New data sheet illustrates maker's switch for regu-

lating low vacuums.—Henry G. Dietz Co., 12 Astoria Blvd., Long Island City 2, N.Y.
Circle **540** on inquiry card.

FLOW



Pitot Equipment. New 20-page Bulletin 1301 presents theory, formulas, tables, and operation of Pitot flow-measuring instruments.—Simplex Valve & Meter Co., 7 East Orange St., Lancaster, Pa.
Circle **541** on inquiry card.

Centrifugal Pumps. New 4-page Bulletin 1030 describes new seal-less centrifugal pumps for leak-proof pumping.—Chempump Corp., 1300 East Mermaid Lane, Philadelphia 18, Pa.
Circle **542** on inquiry card.

Rotameter Kits. New 8-page Bulletin 140 describes maker's line of rotameter kits for laboratory, field, and pilot plant research.—Brooks Rotameter Co., Lansdale, Pa.
Circle **543** on inquiry card.

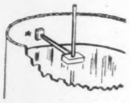
Rotameters. New 20-page Bulletin 115 illustrates features of new full-view rotameters and accessories.—Brooks Rotameter Co., Lansdale, Pa.
Circle **544** on inquiry card.

Purge Meter. New 8-page Bulletin 120 features maker's small flow indicators and regulators.—Brooks Rotameter Co., Lansdale, Pa.
Circle **545** on inquiry card.

Hot-Wire Probes. New 4-page Bulletin 15A presents a complete line of hot wire anemometer probes for measuring velocity and velocity fluctuations, as well as temperature and pressure fluctuations.—Flow Corp., 283 Concord Avenue, Cambridge 38, Mass.
Circle **546** on inquiry card.

Velocity Fluctuation Correlation. New announcement sheet describes hot-wire sum-difference unit to measure correlation between two velocity fluctuations (at same or different points) in an air stream.—Flow Corp., 283 Concord Ave., Cambridge 38, Mass.
Circle **547** on inquiry card.

LEVEL



Liquidometer Systems. New 18-page brochure illustrates capacitor-type systems, gages and controls for liquid fuel measurement in multi-tank storage systems, including aircraft.—The Liquidometer Corp., Long Island City 1, N.Y.
Circle **548** on inquiry card.

Level Proximity Relay. New 2-page sheet, S-1, describes maker's capacitance-operated heavy-duty relay to control non-conductive materials.—Excel Electric Service Co., Inc., 2121 South Western Ave., Chicago 8, Ill.
Circle **549** on inquiry card.

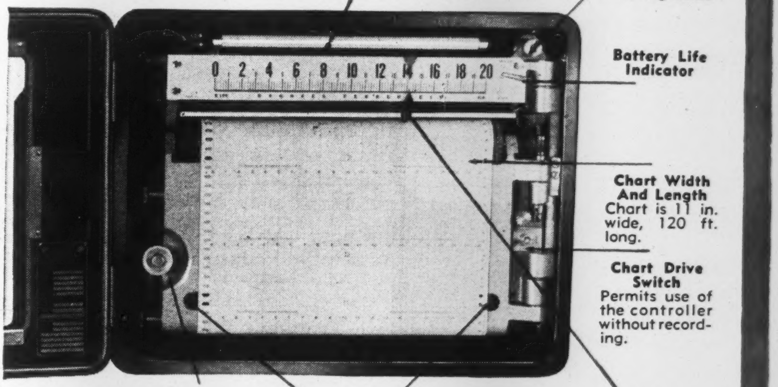
THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

New Series 8000 Potentiometer-Recorder ..tops in accessibility and ease of adjustment

FLUORESCENT LIGHT ILLUMINATES SCALE AND CHART
(Available as an optional extra)
Direct indicating scale—large numerals are easy to see.



Control Point Setting Knob

Battery Life Indicator

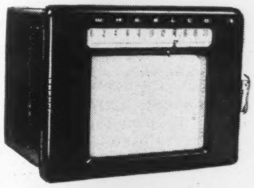
Chart Width And Length
Chart is 11 in. wide, 120 ft. long.

Chart Drive Switch
Permits use of the controller without recording.

Operating Knob
Twist knob to pull out chart, push button to pull out chart and recorder drive assembly.

Finger Holes
Make it easy to grasp chart to refer back.

Full Scale Balancing Speed
Low speed is 15 seconds, high is 2 seconds.



Accessibility and ease of adjustment were primary design considerations when Wheelco developed the new Series 8000 Potentiometer-Recorder. While every Wheelco instrument is built to function with maximum accuracy and minimum maintenance, this new null-balancing type electronic recorder was designed to be especially easy to use.

The front cover swings open 180 deg, thus permitting the chart drive to swing out a similar 180 deg, making the internal mechanism accessible. Wheelco Series 8000 Potentiometer-Recorder is available to measure, indicate, control, and give permanent record of variables such as temperature, speed, strain, hydrogen ion (pH), and any other quantities which can be resolved into electrical signals.

Send for new catalog which gives complete technical information on this latest Wheelco instrument.

WHEELCO INSTRUMENTS DIVISION

Barber-Colman Company

Dept. C, 1515 Rock Street, Rockford, Illinois

BARBER-COLMAN of CANADA, Ltd., Dept. C, Toronto and Montreal, Canada

For more information circle **180** on inquiry card

Measurements Corporation
MODEL 79-B

PULSE GENERATOR

REPETITION RATE: 60 to 100,000 pulses per second.

PULSE WIDTH: Continuously variable from 0.5 to 40 microseconds.

RISE TIME: Approx. 0.25 microseconds.

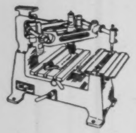
OUTPUT VOLTAGE: 150 volts (peak) positive.

POWER SUPPLY: 117 volts, 50/60 cycles.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

For more information circle **182** on inquiry card

WHICH OF THESE



METALS DO YOU ENGRAVE?

STEEL, STAINLESS STEEL, BRASS, COPPER, NICKEL-SILVER, DIE CAST METAL, ETC.

The PREIS-PANTO Model UE-3 engraver, will engrave lettering or design on all of these metals. Completely contained. Operates as easy "as tracing a drawing."

Write for latest UE-3 catalog. For immediate attention write directly to manufacturer below. Ask for nearest representative.

"TRADE MARK"
PANTO

H. P. PREIS
ENGRAVING MACHINE CO.
661 U. S. Highway 22 Hillside, N. J.

For more information circle **183** on inquiry card

NEW LITERATURE

Level Control. Three new 2-page Bulletins (ALCP-2.1, ALC-2.1 and ALC-3.1) picture and describe maker's "Mek-Probes" level probes and electronic liquid-level control systems.—Machinery Electrification, Inc., 35 Hudson St., Northboro, Mass.

Circle **550** on inquiry card.

THICKNESS, DENSITY

Thickness Gage. New 2-page Bulletin 28P1 describes simple pencil-size gage for measuring thickness of non-magnetic coatings on ferrous bases. Attraction of magnet to structure is used as basis of measurement to 15% or 0.0001 inch.—James G. Biddle Co., 1316 Arch Street, Philadelphia 7, Pa.

Circle **551** on inquiry card.

Beta-Ray Thickness and Weight Control. New 12-page booklet reviews techniques for automatic control of thickness and weight in steel, rubber, plastic, and other industries by maker's "AccuRay" instruments.—Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

Circle **552** on inquiry card.

Gammagage. New 4-page Catalog 14 presents maker's "Gammagage" for continuous control of density for food, chemical, oil, mining and refining industries.—Isotope Products Inc., Instrument Div., Buffalo, N.Y.

Circle **553** on inquiry card.

Beta-gaging. New 4-page issue of Isotope Newsletter (Vol. 5 No. 2.) features articles on "Betameter" thickness controller; also article describing metallurgical problems of atomic reactor operation and design; —Isotope Products, Buffalo, N.Y.

Circle **554** on inquiry card.

SPEED

Hand Tachometers. New 4-page Bulletin AT 135 describes maker's hand tachometers for measuring rotational speeds of shafts, spindles, gears, drums, etc.—Clarence J. Marx Co., P.O. Box 4033, Cleveland 23, Ohio.

Circle **555** on inquiry card.

GAGING, TESTING

Electronic Comparators. New 4-page Bulletin 200 illustrates three models and accessories of maker's electronic comparators for gaging external dimensions.—Metron Instrument Co., 432 Lincoln Street, Denver 3, Col.

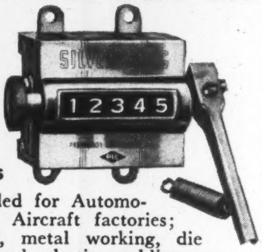
Circle **556** on inquiry card.

Testing facilities. New 4-page brochure describes facilities used in material and product testing, e.g. infrared, spectroscopy, radio isotope, microwave, acceleration, distortion, stability, etc.—Electrical Testing Laboratories, Inc., 2 East End Ave., New York 21, N.Y.

Circle **557** on inquiry card.

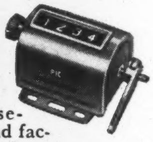
Endurance Rated
COUNTERS
to Fit every need

200 MILLION COUNT LIFE



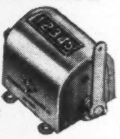
PIC
Silver King Stroke Counters
Unequalled for Automobile and Aircraft factories; stamping, metal working, die casting and plastic molding machines; laundry, printing and all kinds of equipment.

6 MILLION COUNT LIFE



PIC
Junior King
The proven answer for office machines, amusement machines, and factory equipment where service is moderate.

3 MILLION COUNT LIFE

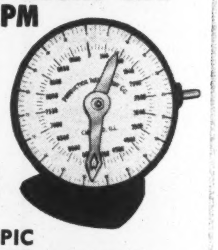


PIC
SMX Tamperproof
Millions used for vending machines and other equipment where space is limited.

200 MILLION COUNT LIFE

PIC
Silver King
Revolution Counter
For measuring machines, metering equipment, etc. Available with flexible shaft for convenient location.

1 BILLION COUNT LIFE
10,000 CPM



PIC
Clipper Coil Winding Counter
Unequalled for high speed coil winding.

See your PIC Representative or write.

PIC
PRODUCTION INSTRUMENT CO.
702 W. Jackson Chicago 6, Ill.

For more information circle **86** on inquiry card

Comparator. New 4-page brochure presents maker's new measuring comparator with standard magnification of 35X and 1mm pitch screw making it possible to read to a fraction of a micron.—Paul M. McPherson Precision Instruments, Acton, Mass.

Circle **558** on inquiry card.

Surface Roughness. New 8-page brochure illustrates production applications of portable "Profilometer," used for measuring surface roughness.—Micrometrical Mfg. Co., 345 South Main St., Ann Arbor, Mich.

Circle **559** on inquiry card.

Portable X-ray Unit. New 2-page brochure illustrates new weatherproof industrial X-ray unit for field projects and semi-permanent in-plant locations.—Balteau Electric Corp., New and Meadow Streets, Stamford, Conn.

Circle **560** on inquiry card.

Automotive Test Equipment. Seven 2-page sheets present an inclusive line of engine test equipment and battery chargers, including distributor testers, compression testers, etc. —King Electric Equipment Co., Cleveland 5, Ohio.

Circle **561** on inquiry card.

TEST CHAMBERS

Environmental Test. New 9-page brochure describes test facilities available for product certification in explosion, dust, shock, radial acceleration and fungus resistance tests.—General Testing Laboratories, Inc., 58 Washington Ave., Carlstadt, N.J.

Circle **562** on inquiry card.

Test Chambers. New 4-page catalog presents models of maker's low-temperature chilling chambers; 2-page data sheet presents new 12-cu-ft chamber with temperature control from -100 to $+200°$ F.—Harris Refrigeration Co., 365 Walden St., Cambridge, Mass.

Circle **563** on inquiry card.

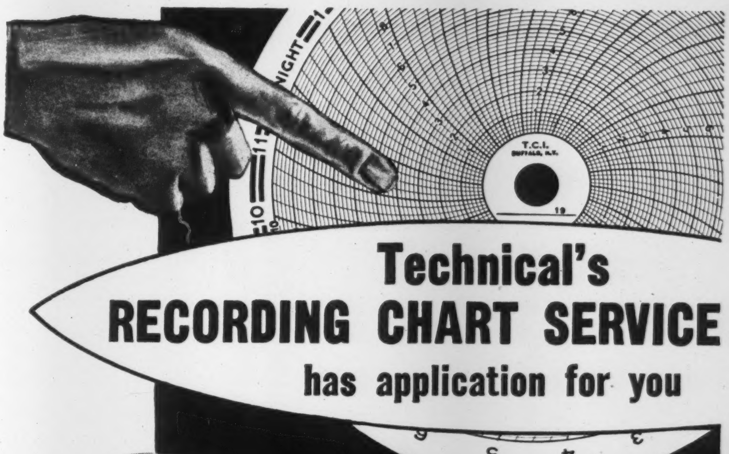
RADIOACTIVITY

Radiation Processing. New 34-page Bulletin E surveys processing, sterilization and research applications of radiation equipment, and provides data on maker's electron accelerators. —High Voltage Engineering Corp., 7 University Road, Cambridge 38, Mass.

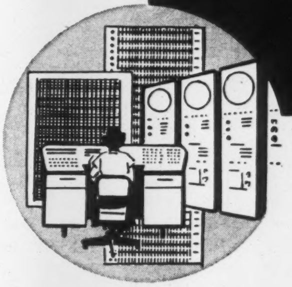
Circle **564** on inquiry card.

Radioactivity Instruments. New 24-page catalog 5-A presents principles, specifications, prices and descriptions of pulse height analyzers, scalers, panels, meters and related accessories.—Detectolab, Inc. 6544 N. Sheridan Rd., Chicago 26, Ill.

Circle **565** on inquiry card.

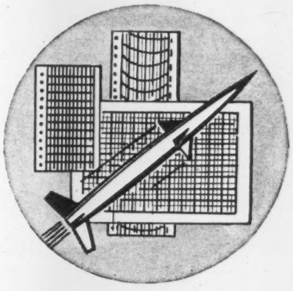


Technical's
RECORDING CHART SERVICE
has application for you



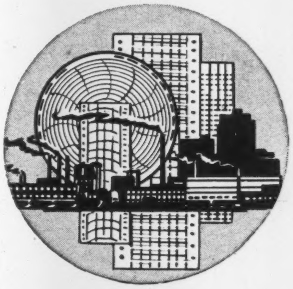
DIGITAL COMPUTER RECORDS . . .

Are you satisfied with your present computer recording forms? Contact **Technical** for help in developing computer or tabulating machine forms best suited for your statistical applications. Information on **Technical's** "know-how" with computer papers sent upon request.



"SPECIAL" RECORDING CHARTS . . .
for new instruments or unusual process needs!

Charts are vital to the **new recording instrument** design. Be sure you contact **Technical** when your project begins and eliminate recording problems at the start! For standard instruments recording under unusual process conditions, **Technical** can supply "Special" charts on heat or electro sensitive and other papers. Send for "Technical Notes" containing helpful new chart specifications.



8000 STANDARD CHARTS . . .
await your call!

Chart supply is easy . . . and operating costs are less . . . when you suggest to your purchasing men to buy **all** their chart needs from **Technical. Technical's** acceptance by large and small "Blue Chip" companies is testimony of high chart quality. Automatic order processing and inventory control assure fast service. Write for Catalog 56 and stock list.

BLUE CHIP TCI ACCEPTANCE

Serving America's Foremost Industries

TECHNICAL CHARTS INCORPORATED
BUFFALO 10, N. Y.

Nationally Represented by TECHNICAL SALES CORPORATION
16599 Meyers Road, Detroit 35, Michigan

STANDARD CHARTS • SPECIAL CHARTS • COMPUTER PRINTING AND PLOTTING PAPER

For more information circle **184** on inquiry card

MINIATURIZED CONTROL

with New Types of Packless "DEMI"® VALVES

"Demi" Toggle Action is improved in the valve shown at the left. Positive indication of seat position is provided, with the same rugged, pinless toggle as in standard "Demi" Toggle Valves. Rating: 0-250 psig, —100 to +250°F. In globe, 3-way or manifold styles.

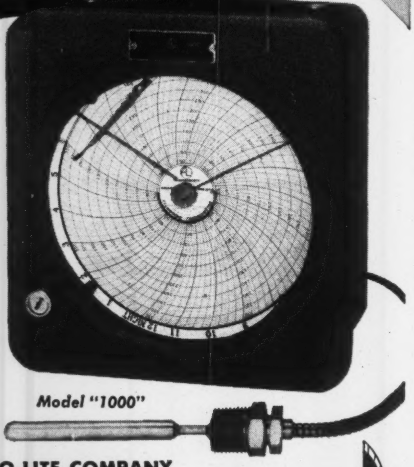
"Demi" Air Operated valves are typified by the center valve. For remote operation, with compact, interchangeable operation and body assemblies. A wide choice of materials is available. Body assembly rating: 0-1500 psig, —400 to +700°F. Operator rating: 160 psig, Max.

"Demi" Engineered valves for special applications, as shown on the right. Thousands of these valves are now protecting coaxial cables. An 18-8 stainless steel diaphragm seal assures years of leak-proof operation. Even liquid sodium is controlled by special "Demi" valves. Let us "miniaturize" your valve engineering problems.

Write for Complete Catalog and Name of our Representative in your area.

GEORGE W. DAHL CO. INC.
BRISTOL • RHODE ISLAND

For more information circle **185** on inquiry card



AUTO-LITE

TEMPERATURE RECORDING...

Newly designed, Model "1000" Auto-Lite Recorder gives permanent proof of temperature behavior. • 6" clear reading chart; various standard ranges from minus 40°F. to plus 550°F. • 3 standard types; choice of 24-hr. or 7-day cycle. • Electric or mechanical chart drive. • With capillary tubing for remote reading. Priced from $49.50.

Send for new catalog describing many styles of Auto-Lite temperature Recorders and Indicators.

Model "1000"

THE ELECTRIC AUTO-LITE COMPANY
INSTRUMENT AND GAUGE DIVISION
TOLEDO 1, OHIO
NEW YORK • CHICAGO • SARNIA, ONTARIO

TEMPERATURE RECORDERS

For more information circle **186** on inquiry card

NEW LITERATURE

Proportional Counters. New 2-page brochure describes maker's proportional counters for radioactivity measurement.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Indiana.

Circle **566** on inquiry card.

Radioisotopes. New 4-page catalog describes accelerator-produced radioisotopes, including availability and prices.—Nuclear Science and Engineering Corp., P.O. Box 10901, Pgh. 36, Pa.

Circle **567** on inquiry card.

Betameter. New 8-page Catalogue No. 10 presents maker's new "Betameter" for measurement and control of all sheet materials.—Isotope Products Inc., Instrument Div., Buffalo, N.Y.

Circle **568** on inquiry card.

Geiger Counter. New 4-page brochure describes maker's portable geiger counter for uranium prospecting. Unit measures beta and gamma radiation of low and medium intensities. —Nuclear Instrument and Chemical Corp., 223 W. Erie St., Chicago 10, Ill.

Circle **569** on inquiry card.

Gamma Logger. New 4-page brochure presents maker's new portable borehole logging unit.—Moran Radiation Survey Equip. 170 East Orange Grove Ave., Pasadena 3, Calif.

Circle **570** on inquiry card.

DATA RECORDING

Data Recording. New 4-page Bulletin 107 describes maker's FM-Carrier recording system using magnetic tape.—A-V Mfg. Corp., 730 Fifth Ave., New York 19, N.Y.

Circle **571** on inquiry card.

Battery-Operated Tape Recorder. New 4-page brochure describes line of battery-operated, spring-motor tape recorder with high-inertia balanced flywheel for low flutter.—Amplifier Corp. of America, 398 Broadway, New York 13, N.Y.

Circle **572** on inquiry card.

Digital Data Recorder. New 2-page Bulletin 470 presents new digital data recorder for strain gage recording, static and dynamic testing, multichannel monitoring and process plant control.—Beckman Division, Beckman Instruments, Inc., Fullerton, Calif.

Circle **573** on inquiry card.

SEISMOGRAPHS, ACCELEROMETERS

Seismograph. New 6-page brochure S-309 describes maker's seismograph permitting linearity over frequency range of 3-500 cycles per second.—Houston Technical Laboratories, 242 Branard, Houston 6, Texas.

Circle **574** on inquiry card.

Seismograph. New 4-page brochure describes portable blast and vibration seismograph that records three components photographically on a single 2¾″ strip of paper.—W. F. Sprengnether Instrument Co., Inc., 4567 Swan Ave., St. Louis 10, Mo.

Circle **575** on inquiry card.

Accelerometers. New 2-page Bulletin AA3-I describes maker's inductive accelerometers, liquid rotor and angular. Bulletin AA3-A presents unbonded-strain-gage liquid-rotor angular accelerometers.—Statham Laboratories, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle **576** on inquiry card.

COMPUTING

Magnetic Drums, Heads. New 4-page brochure presents various models and performance characteristics of maker's read and record heads, and magnetic drums for storage, buffer, etc.—Librascope, Inc., 808 Western Ave., Glendale, Calif.

Circle **577** on inquiry card.

Analog Computer. New 6-page brochure describes new desk console general-purpose computer.—Weber Aircraft Corp., 2820 Ontario St., Burbank, Calif.

Circle **578** on inquiry card.

Translators. Analog-to-Digital Converter. New 8-page reprint is on theory and application of maker's high-speed voltage-to-digital translators.—EPSCO, Inc., 588 Commonwealth Ave., Boston, Mass.

Circle **579** on inquiry card.

COUNTING

Bi-Directional Counters. New 4-page brochure presents new summation counter and zero level counter with dynamically balanced bi-directional movement.—Nemeth, Inc., 2223 S. Carmelina, Los Angeles 64, Calif.

Circle **580** on inquiry card.

OPTICS

Coded Dials, Discs. New 4-page brochure describes optical techniques used by maker to divide circles into as many as 2,000 lines per peripheral inch and to make coded discs, dials, etc.—Precision Photomechanical Corp., 170 S. Van Brunt St., Englewood, N. J.

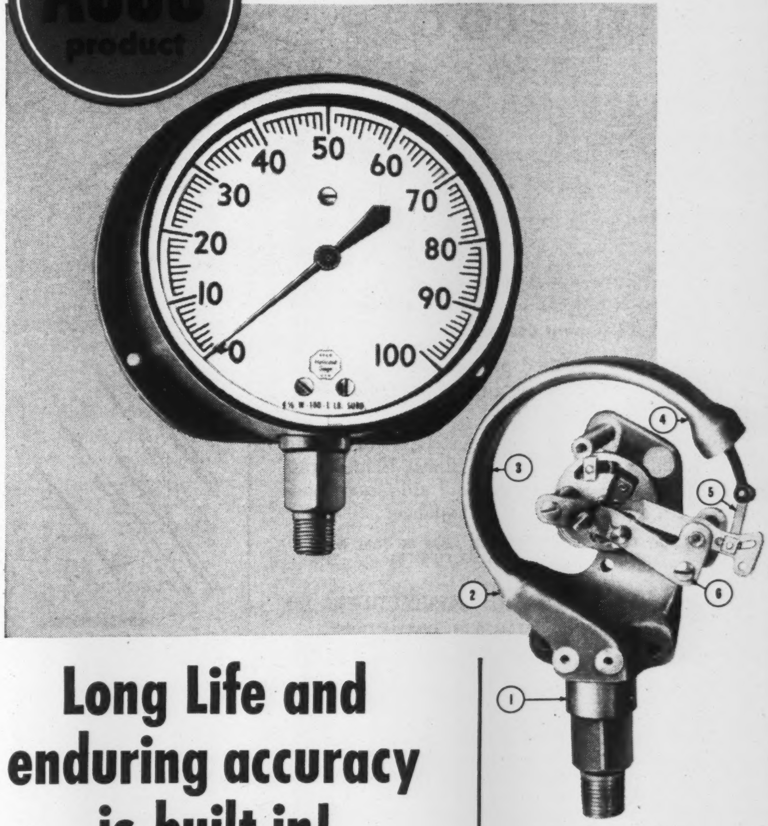
Circle **581** on inquiry card.

Optical equipment. New 62-page catalog presents maker's line of optical equipment and supplies—mirrors, telescopes, binoculars, enlargers, cameras, lenses, prisms, etc.—Edmund Scientific Corp., Barrington 6, New Jersey.

Circle **582** on inquiry card.

an ACCO product

Helicoid Gages



Long Life and enduring accuracy is built in!

• Sustained accuracy of HELICOID Gages through years of hard service comes from superior design and construction.

The HELICOID Gage has many unique and exclusive features. It is not only a pressure instrument of the utmost precision but one that requires but a minimum of maintenance throughout a long service life.

The smooth rotation of the spiral movement and cam outlasts and outperforms other gage types. There are no gear teeth to wear out.

HELICOID Gages are available to meet every type of pressure indicating requirement. Ranges are from 15 to 20,000 p.s.i. and vacuum or compound.

Write for catalog today

Why HELICOID Gages last longer!

Socket (1) is one-piece drop forging, streamlined to reduce possibility of clogging.

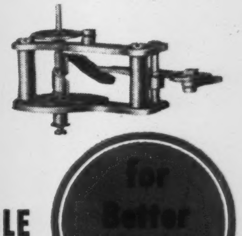
Bourdon tube* (3) is alloy steel, stainless steel or K Monel.

Tube is welded to forged socket (2) and tip (4).

Connecting link and link screws (5) are K Monel.

Helicoid movement (6) is corrosion resistant.

*Phosphor bronze tube also available.



ACCO

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-B Connecticut Avenue • Bridgeport 2, Connecticut

TRADE MARK

for Better Value

For more information circle **187** on inquiry card

Wendon
Mini-Tools

Hand tools used in fractional horse power motor assembly

- **Armature coil and stator winding**
- **Inserting coils in stators and armatures**
- **Various instrument assemblies**

where a highly polished pick or probe is needed to prevent scratching, digging or marring of finished surfaces.

Made of high tempered spring steel, hand ground and buffed to a lustrous natural finish. Blades press fitted into non-rolling hexagonal aluminum handles for lightness and perfect balance.

PRICED AT LEAST 50% BELOW THE COST OF TOOL ROOM MADE PROBES, PICKS OR PUSHERS

Wendon MANUFACTURING CO.
17 IRVING AVENUE, STAMFORD, CONNECTICUT

6
Basic Designs
Over 30 sizes and styles to meet specific needs.

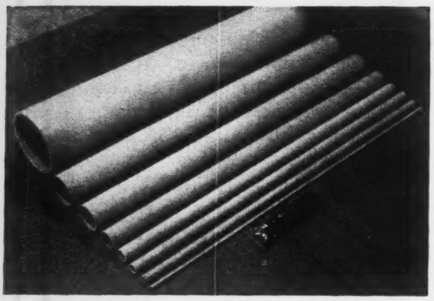
Fully Guaranteed
Write for 1956 Catalog.

For more information circle **188** on inquiry card

McDANEL

. . . HIGH TEMPERATURE *Ceramic*
PROTECTION TUBES
Large or Small
Designed for Your
INSTRUMENTS . . .

● Need protection tubes in your instruments? McDanel Ceramic Protection Tubes, glazed or unglazed are guaranteed for dependable service in temperatures up to 2900° F. They have good thermal shock qualities and a low co-efficient of expansion.



● McDanel Protection Tubes are gas tight. Precision manufacturing control assures a quality product capable of long, dependable performance. We make standard and special sizes! Send us your specifications.

McDANEL
Industrial
CERAMICS

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS . PENNSYLVANIA

Send for Bulletin PI-55 TODAY!

For more information circle **189** on inquiry card

NEW LITERATURE

ULTRASONICS

Ultrasonic Transducers. New 12-page descriptive booklet illustrates maker's "Glennite" piezoelectric ceramic transducers.—Gulton Mfg. Corp., Metuchen, N. J.
Circle **583** on inquiry card.

Ultrasonic Inspection. New 8-page Bulletin 50-105 presents data on maker's "Reflectoscope" for ultrasonic detection and location of defects in materials.—Sperry Products, Inc., Danbury, Conn.
Circle **584** on inquiry card.

LABORATORY

Lab Apparatus. New 12-page issue of "Review" (No. 6) describes equipment receiving greatest call in 195 (balances, reagents, etc.) and features a 4-page section on "Harleco" volumetric solution concentrates.—Arthu S. LaPine & Co., 6001 South Knox Ave., Chicago 29, Ill.
Circle **585** on inquiry card.

Laboratory Furniture. New 12-pag catalog presents maker's laborator units and fixtures.—Metalab Equipment Co. Hicksville, Long Island N. Y.
Circle **586** on inquiry card.

Electric Ovens. New 68-page catalog presents maker's electric ovens furnaces, water and oil baths, humidity cabinets, and incubators.—Blu M Electric Co., 138th and Chatham St., Blue Island, Ill.
Circle **587** on inquiry card.

Ovens. New 4-page Bulletin 5510-1 describes conditioning ovens, sampl drying ovens and silicone rubber curing ovens.—National Appliance Co. 7634 S. W. Capital Hwy., Portlan 19, Oregon.
Circle **588** on inquiry card.

Utility Ovens. New 2-page bulleti describes maker's "Models CA-250 CA-650, CA-550 and CA-1000" utilit ovens.—New England Oven & Furnac Co., Inc., Orange, Conn.
Circle **589** on inquiry card.

ANALYTICAL

Light-Scattering Photometers. Nev 22-page Bulletin B-P 1000 A describe line of light-scattering photometer and accessories for molecular weight turbidimetry, fluoremetric analysis etc.—Phoenix Precision Instrumen Co., 3803 N. 5th St., Phila. 40, Pa.
Circle **590** on inquiry card.

Spectrographic Supplies. New 24 page Catalog SS-8-55 contains listing of special pure materials and allo standards, including carbon and gra

phite rods and powders; preformed electrodes; photographic plates, film and processing chemicals; reference lists, etc.—Jarrell-Ash Co. 26 Farwell St., Newtonville, Mass.
Circle **591** on inquiry card.

NMR Spectroscopy. New 4-page special bulletin illustrates results of new super-high-resolution spectrometer incorporating improved time stability and field uniformity.—Varian Associates, Instrument Division, 611 Hansen Way, Palo Alto, Calif.
Circle **592** on inquiry card.

Mirror-Monochromators. New 10-page Booklet 980 provides specifications on maker's single and double mirror-monochromators applicable over the spectral range from ultraviolet to infrared.—Photovolt Corp., 5 Madison Ave., New York 16, N.Y.
Circle **593** on inquiry card.

Air Polutant Recorder. New 7-page report illustrates maker's system for colorimeter analysis and recording concentrations of gases or vapors in air or other gases.—Harold Kruger Instruments, P.O. Box 164, San Gabriel, Calif.
Circle **594** on inquiry card.

Flame Photometer. New 18-page manual describes new, imported flame photometer particularly advantageous for quick, quantitative analyses of alkalis and akaline earths.—Epic, Inc., 154 Nassau St., New York 38, N. Y.
Circle **595** on inquiry card.

Oxygen-Electrode Appartus. New 2-page bulletin presents polarographic method for determining changes in oxygen tension in biological materials.—Kilpatrick Electronic Laboratory, Box 61, Norristown, Pa.
Circle **596** on inquiry card.

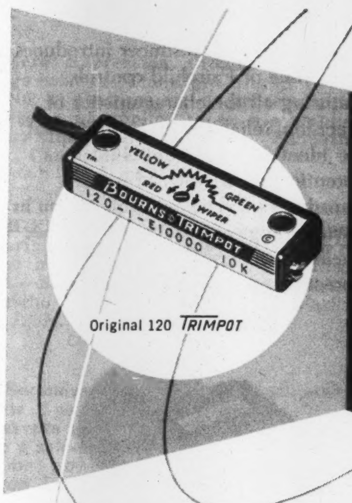
MAGNETICS

Permanent Magnets. New 15 pages of additions to 20-page Bulletin PM 100 cover large line of "Alnico" permanent magnets.—Permag Corp., 214 Taaffe Place, Brooklyn 5, N. Y.
Circle **597** on inquiry card.

Magnetic Chucks. New 22-page Catalog No. 412 describes line of rectangular, rotary and sine-angle magnetic chucks and magnetic work drivers.—Taft-Peirce Mfg. Co., Woonsocket, R. I.
Circle **598** on inquiry card.

AIRCRAFT

Helicopter Navigation. New 108-page report "Helicopter Navigation Requirements" presented by Stanford Research Institute, presents requirements for aids to navigation of helicopters operating in the period 1958-1965.—Pacific Div., Bendix Aviation Corp., 11600 Sherman Way, North Hollywood, Calif.
Circle **599** on inquiry card.



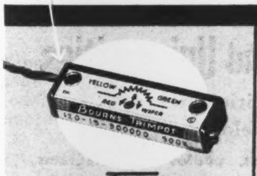
BOURNS now offers an expanded line of TRIMPOTS®

...7 stock models of sub-miniature potentiometers to serve many special needs—at no extra cost!

First there's the 120 Wirewound TRIMPOT, with features common to all other BOURNS TRIMPOTS. It's a 25-turn potentiometer, easily adjusted, and weighing only 0.1 oz. Rectangular in shape, it fits readily into miniature electronic circuits. You can mount it individually, or stack it compactly with standard screws. Mountings are interchangeable with those on all other TRIMPOTS.

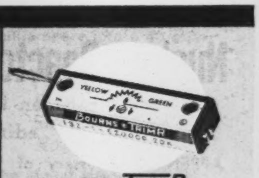
The self-locking shaft holds stable settings under extreme environmental conditions. All parts are corrosion resistant. Every unit is inspected 100% for guaranteed specifications. Resistances: 10 to 20,000 ohms, with resolutions as low as 0.2%.

Now, to give designers greater latitude, BOURNS has developed and is manufacturing the following standard models—variations of the Model 120.



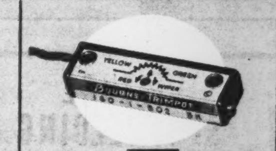
120 TRIMPOT
—Carbon
Infinite resolution is provided by the carbon element. Resistances are higher, ranging from 20,000 ohms to 1 megohm.

130 TRIMPOT
—Solder Lug
For wiring direct to the instrument, using soldering iron or dip soldering techniques. Usable range of 98%.



132 TRIMR
—Variable Resistor
High resistances—up to 50,000 ohms in a wirewound rheostat.

209 TWINPOT
—Dual Potentiometer
Two outputs electrically independent, and controlled simultaneously by one adjustment.



160 TRIMPOT
—High Temperature
Operates at 175°C. High power rating: 0.6 watt at 50°C.

230 TRIMPOT
—Humidity-proof
Completely sealed, unit meets MIL-E-5272A Specifications for humidity.

Write for literature on the BOURNS TRIMPOT line.

BOURNS LABORATORIES
General Offices: 6135 Magnolia Ave., Riverside, Calif.
Plants: Riverside, California—Ames, Iowa

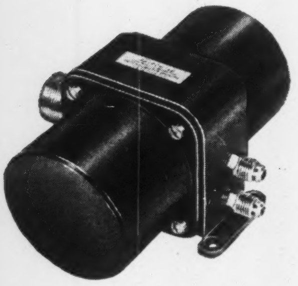
For more information circle **190** on inquiry card

PRESSURE TRANSDUCERS

featuring Fairchild accuracy and reliability

The unit shown features two pressure-sensitive diaphragm elements which actuate two precision potentiometers through a dynamically-balanced, stable mechanical linkage. Variations of size, conformation and pressure ranges for measurement of differential, absolute or gauge pressures are also available. For complete information, write Fairchild Controls Corp., Components Division, 225 Park Avenue, Hicksville, L. I., N. Y.; **West Coast:** 6111 E. Washington Blvd., Los Angeles, Calif., Dept. 140-70B.

The TPD-300 Transducer introduces a new line of Fairchild controls, featuring all the characteristics of precision, reliability and quality that are identified with Fairchild potentiometers. Now, pressure transducers will be available to you in a wider range of resistances in either linear or functional, single or dual potentiometer output elements.



FAIRCHILD
PRECISION POTENTIOMETERS
PRESSURE TRANSDUCERS

For more information circle **191** on inquiry card

" . . . first book on small research reactors."

Nuclear Reactors for Industry and Universities

written by eight eminent authorities and edited by Ernest H. Wakefield

APPENDIX—Glossary of Terminology, Cloth, 102 pages, photos and diagrams, 4-page index.

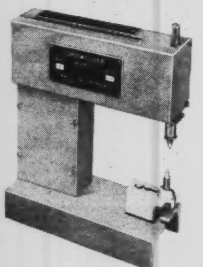
$2.00 postpaid

Remittance must accompany order

INSTRUMENTS PUBLISHING CO.
845 Ridge Avenue, Pittsburgh 12, Pa.

MINIATURE SPOTWELDING EQUIPMENT

WELDING HEAD WHD 4



For small precision welds on materials .0005 to .1" thick

PRESSURE adjustable on calibrated scales ¼ ounce to 15 lbs.

FORGING ACTION through ultra-low moving mass

- **POWER PLANTS** Stored energy and small A-C Types
- **TAPWELDERS FLASH-FLOW** © welder for potentiometer taps

We specialize in equipment for welding miniature parts. Ask for data sheets and submit your parts for sample welds.

EWALD INSTRUMENTS
93 Nassau Street, New York 38, N. Y.

For more information circle **192** on inquiry card

NEW LITERATURE

POWER SUPPLIES

Selenium Rectifier. New 8-page Bulletin MI describes physical and electrical characteristics of maker's selenium rectifiers for printed circuitry.—Federal Telephone and Radio Co., 100 Kingsland Road, Clifton, N. J.

Circle **600** on inquiry card.

Germanium Rectifiers. New 4-page Bulletin GR-100 describes and illustrates maker's germanium rectifiers. —Hanson-Van Winkle-Munning Co., Church St., Matawan, N. J.

Circle **601** on inquiry card.

Generator Control. New 2-page bulletin presents maker's packaged generator control units with both automatic and manual voltage regulation for AC generators to 150 KW.—The Simplex Co., Springfield, Ill.

Circle **602** on inquiry card.

Dynamotors. New 4-page Bulletin 00-411 describes maker's new line of dynamotors.—Sangamo Generators, Inc., 2110 Clear Lake Ave., Springfield, Ill.

Circle **603** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Oscilloscopes, Test Equipment. New 12-page Catalog 52-A presents general purpose and laboratory oscilloscopes, vacuum-tube voltmeters, signal generators, mutual conductance and emission tube tester, and other circuit trouble-shooting apparatus.—Precise Developement Corp., Oceanside, N. Y.

Circle **604** on inquiry card.

Packaged Modular Circuits. New 14-page Engineering Bulletin 450-1 describes new "PAC" packaged assembly circuit for modular electronic assembly. Includes typical circuits.—first video i-f stage, sync phase inverter, etc.—Erie Resistor Corp., Erie, Pa.

Circle **605** on inquiry card.

VTVM. New 4-page issue of "Hewlett-Packard Journal" (Vol. 7, No. 4) features articles on "An Enhanced Accuracy High Readability VTVM," and "Use of the Notch Wattmeter." —Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **606** on inquiry card.

Phase Shift Measurement. New 4-page article "Precision Phase Shift Measurements" describes procedure to measure phase shifts to 0.01 degree. New 2-page brochure illustrates phase meter for precision measurements.—Industrial Test Equipment Co., 55 East 11th St., New York 3, N. Y.

Circle **607** on inquiry card.

Molded
BLACK NYLON SCREWS and NUTS

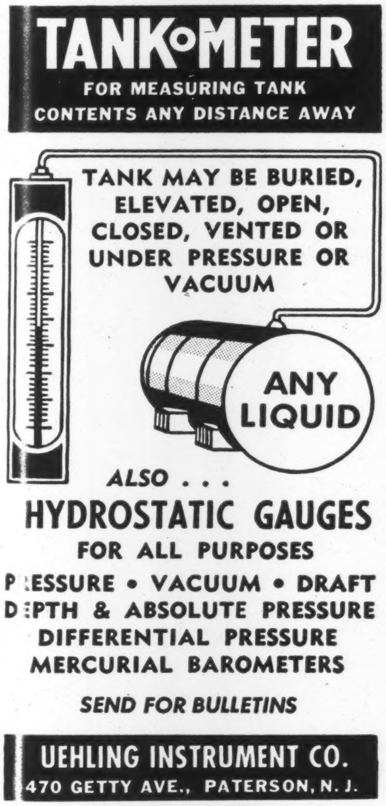
Insulate and fasten without bushings, washers, etc.
In stock 6-32, 8-32, 10-32

NyGrip BLACK NYLON Cable Clips

Light-weight non-conducting support for wiring, tubing, etc.
In stock 1/16" to 1½" dia.

Free Samples...Write
WECKESSER CO.
5258 N. Avondale Avenue • Chicago 30, Illinois

For more information circle 193 on inquiry card


TANK-O-METER
FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

ANY LIQUID

ALSO . . .
HYDROSTATIC GAUGES
FOR ALL PURPOSES
PRESSURE • VACUUM • DRAFT
DEPTH & ABSOLUTE PRESSURE
DIFFERENTIAL PRESSURE
MERCURIAL BAROMETERS

SEND FOR BULLETINS

UEHLING INSTRUMENT CO.
470 GETTY AVE., PATERSON, N. J.

For more information circle 194 on inquiry card

Zero Supression Circuit. New 8-page issue of "The Right Angle" (Vol. 3 No. 2) features article on zero suppression as applied to an a-c amplifier.—Industrial Division, Sanborn Co., Cambridge 39, Mass.
Circle **608** on inquiry card.

H-F Direction Finding. New 4-page reprint features article on maker's new high-frequency direction-finding set.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.
Circle **609** on inquiry card.

Secondary Standard Indicator. New 2-page Catalog Sheet No. 1004 presents multi-range DC milliammeter; a self-contained, ready-to-use precision portable instrument.—Phaostron Instrument and Electronic Co., 151 Pasadena Ave., South Pasadena, Calif.
Circle **610** on inquiry card.

Electrical Test Instruments. New 16-page Bulletin 19-56 describes 1956 line of maker's instruments—resistance testers, fault locaters, frequency meters, relays, galvanometers, Frahm resonant-reed relays, Tinsley thickness gages, etc.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.
Circle **611** on inquiry card.

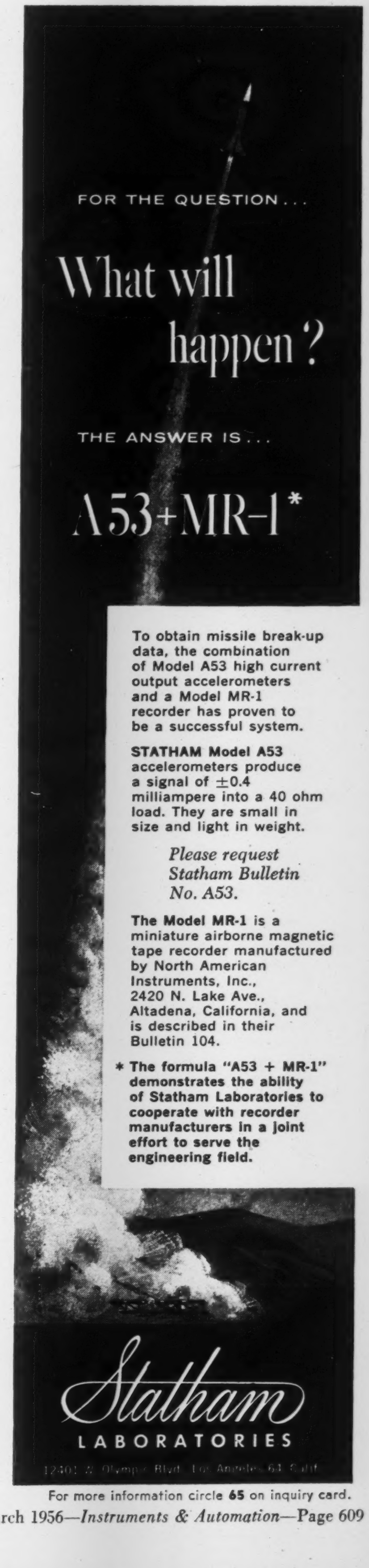
Electronic Test-Instruments. New 6-page Leaflet 52-A describes maker's 'Model 630" RF-AF-TV marker generator, "Model 909" vacuum-tube voltmeter, high-voltage probe, etc.—Precise Development Corp., Oceanside, N. Y.
Circle **612** on inquiry card.

Vibrating-Reed Electrometer. New 4-page bulletin describes maker's "Model 31" Cary vibrating reed electrometer for measuring currents to 1 x 10^{-17} amp.—Applied Physics Corp., 362 W. Colorado St., Pasadena, Calif.
Circle **613** on inquiry card.

Electronic Test Instruments. Six new 2-page bulletins describe maker's "Model 478" capacity decade box, "Model 315" 5" oscilloscope, "Model 111" emission tube tester, "Model 305R" industrial oscilloscope, and 'Model 909W" vacuum-tube voltmeter.—Precise Development Corp., Oceanside, N. Y.
Circle **614** on inquiry card.

AF Wave Analyzer. New 4-page pamphlet describes wave analyzer with constant selectivity over audio-frequency range.—Federal Telephone & Radio Co., 100 Kingsland Rd., Clifton, N. J.
Circle **615** on inquiry card.

Custom Electronic Equipment. New 4-page brochure presents information on design, development and production of custom-built electronic equipment—maker's regulators, power supplies, electrical distribution equipment, printed circuits, etc.—El Mec Laboratories, Inc., 730 Boulevard, Kenilworth, N. J.
Circle **616** on inquiry card.


FOR THE QUESTION...
What will happen?
THE ANSWER IS...
A53+MR-1*

To obtain missile break-up data, the combination of Model A53 high current output accelerometers and a Model MR-1 recorder has proven to be a successful system.

STATHAM Model A53 accelerometers produce a signal of ±0.4 milliampere into a 40 ohm load. They are small in size and light in weight.

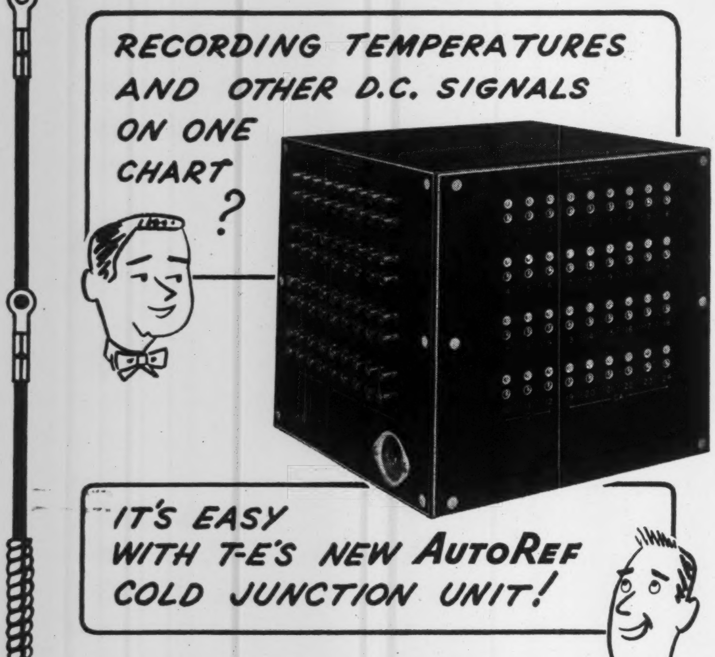
Please request Statham Bulletin No. A53.

The Model MR-1 is a miniature airborne magnetic tape recorder manufactured by North American Instruments, Inc., 2420 N. Lake Ave., Altadena, California, and is described in their Bulletin 104.

* The formula "A53 + MR-1" demonstrates the ability of Statham Laboratories to cooperate with recorder manufacturers in a joint effort to serve the engineering field.

Statham
LABORATORIES
12401 W. Olympic Blvd. Los Angeles 64, Calif.

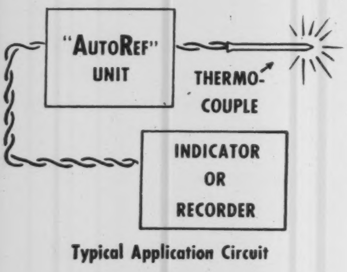
For more information circle 65 on inquiry card.


RECORDING TEMPERATURES AND OTHER D.C. SIGNALS ON ONE CHART ?
IT'S EASY WITH T-E'S NEW AUTOREF COLD JUNCTION UNIT!

It's easy now . . . because Thermo Electric has solved *one main* difficulty involved in such multiple recordings—cold-end compensation for the thermocouple circuits. T-E's "AutoRef" Cold-Junction Units provide a simple, yet accurate solution—constant, predetermined temperature in one, multi-thermocouple reference junction—no longer is there any need for carefully maintained ice baths.

Typically, cold-junction temperatures are controlled to ±1° F. over outdoor ambient temperature range. The "AutoRef" Junction can be conveniently placed anywhere in the thermocouple circuit with copper output leads connecting it to indicating or recording instruments.

A typical unit of 36 circuits (illustrated) measures 12"x12"x12" and weighs 25 lbs. Case-type and capacity can be modified, however, to meet specific needs. For example, the "AutoRef" is also available for standard relay-rack mounting. In any operation requiring multiple recording of temperatures and other conditions these "AutoRef" Cold-Junction Units set new standards of convenience and efficiency without loss of accuracy.



Typical Application Circuit

LIKE TO KNOW MORE? WRITE FOR BULLETIN 80—F.

Pyrometers • Temperature Monitoring Systems • Thermocouples • Protection Tubes Quick-Coupling Connectors and Panels • Thermocouple and Extension Wires

Thermo Electric Co., Inc.

Rochelle Park Post Office, SADDLE BROOK, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

For more information circle **195** on inquiry card

NEW LITERATURE

White-dot Generator. New 2-page illustrated Bulletin A-103 describes maker's "Model 434 Varidot" white-dot generator and "Colorscope" TV test equipment.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **617** on inquiry card.

Electrical, Electronic Test Equipment. New 4-page Bulletin 3001 presents specifications on makers AC-DC volt ohmmeters, battery testers, volt-wattmeters, and "Therm-O-Meter" refrigeration test unit that measures 3 temperatures at 3 locations simultaneously.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **618** on inquiry card.

Airborne Amplifiers, Power Supplies. New 4-page bulletin pictures and describes makers autopilot amplifiers and components, airborne power supplies, voltage regulators, etc.—Hufford Machine Works, Inc., 2201 Carmelina Ave., Los Angeles, 64, Calif.

Circle **619** on inquiry card.

Traveling-Wave-Tube Amplifiers. New 4-page issue of "hp Journal" (Vol. 7 No. 5) features article on new traveling-wave-tube amplifiers with provision for simulating special microwave signals.—Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.

Circle **620** on inquiry card.

Panoramic Receiver. New 4-page bulletin describes new panoramic receiver utilizing "Increductor" controllable inductor for scanning VHF spectrum from 1000 to 150 Mc.—CGS Laboratories, Inc., 391 Ludlow Street, Stamford, Conn.

Circle **621** on inquiry card.

Deflection Indicator. New 8-page Bulletin 05B8385 describes maker's magnetic-amplifier type deflection indicator for shaft-bearing monitoring, drive-shaft positioning, etc.—Allis-Chalmers Mfg. Co., 942 S. 70th St., Milwaukee, Wis.

Circle **622** on inquiry card.

Autotransformer. New 12-page issue of "Experimenter" (Vol. 30, No. 7) features article on "Type W5 Variac—A New and Better Variable Autotransformer."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **623** on inquiry card.

Screen-Booth Filters. New 2-page Engineering Bulletin F-108 describes maker's screen-booth filters used in power-supply lines to shielded test rooms.—Tobe Deutschmann Corp., Norwood, Mass.

Circle **624** on inquiry card.

Synchronizing Generators. New 4-page and 1-page bulletins describe new synchronizing units. One provides completely automatic synchronization of stroboscopic lights for slow motion observation of shake tests.

Other unit (sawtooth generator) produces linear time-base sweep synchronized with external reference signal. —Chadwick-Helmuth Co., Box 321 Monrovia, Calif.
Circle **625** on inquiry card.

Diode Curve Tracer. New 2-page advanced data sheet provides specifications on new model of maker's diode curve tracer with forward and reverse characteristics.—Water Mfg., Inc., 4 Gordon Street, Waltham 54, Mass.
Circle **626** on inquiry card.

Transistor Testers. New 2-page data sheet presents maker's noise figure meter, alpha, and comparison testers.—Electronic Research Associates, Inc., 67 East Centre St., Nutley, N. J.
Circle **627** on inquiry card.

Calibrating Test Equipment. New 24-page issue of "The Capacitor" (Vol. 21, No. 1) features article on calibration techniques for test equipment.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, New Jersey.
Circle **628** on inquiry card.

POTENTIOMETERS

Multiturn Potentiometer. New 2-page sheet provides application, electrical and mechanical data on maker's potentiometer for accurate, linear conversion of rotation to voltage or resistance over a range of ten revolutions.—Analogue Controls, Inc., 39 Roselle St., Mineola, N. Y.
Circle **629** on inquiry card.

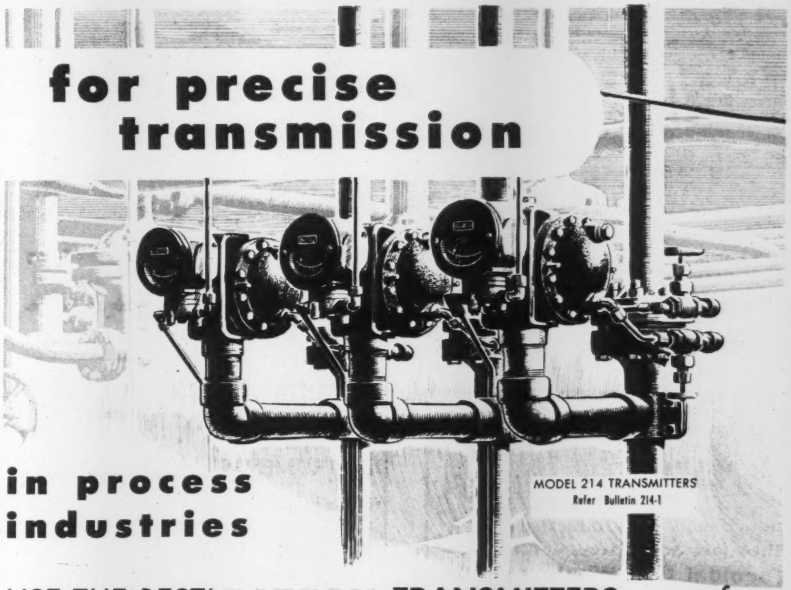
Precision Potentiometers. New 4-page brochure SB-755 presents complete operating and dimensional specs of standard minature and micro-miniature wire-wound potentiometers of high dissipation in sealed units.—Waters Mfg., Inc., 4 Gordon St., Waltham, Mass.
Circle **630** on inquiry card.

Shaft-Angle Setting. New 2-page advanced data sheet illustrates maker's "Anglyzer" that permits precise shaft-angle settings of potentiometers and switches to 0.1 degree.—Waters Mfg., Inc., 4 Gordon Street, Walthem 54, Mass.
Circle **631** on inquiry card.

RELAYS, SWITCHES

Mercury-Switch Controls. New 56-page Catalog 856 describes maker's Mercoid mercury-switch-type controls for pressure, temperature, pressure-differential, combustion control, motor control, etc.—Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Circle **632** on inquiry card.

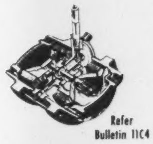
for precise transmission

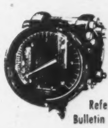


in process industries

USE THE BEST! BARTON **TRANSMITTERS** outperform the leaders ! Accurately measures flow, liquid level and differential pressure. Transmits with high speed, high sensitivity and low air consumption. Unaffected by vibration, over-range, temperature variation and pulsation. Ranges from 0-20" W. C. to 0-400" W. C., and S.W. P. to 6000 psig.

For further information request Bulletin 214-1 or contact BARTON sales engineers in most principal cities.


Refer Bulletin 11C4
MODEL 199 METER BODY


Refer Bulletin 11C4
MODEL 200 INDICATOR

Refer Bulletin 11C4
MODEL 202 RECORDER

Refer Bulletin 211-1
MODEL 211 FLOW SWITCH

BARTON **INSTRUMENT CORPORATION**
INDUSTRIAL INSTRUMENTS
1429 SOUTH EASTERN AVENUE · LOS ANGELES 22, CALIFORNIA
For more information circle **196** on inquiry card

BALZERS Thin Film Optics

From the Principality of Leichtenstein Swiss Customs Area

ROLYN ARCADIA (Calif.)

Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

CABLE ADDRESS
"ROLYN" LOS ANGELES
PHONE: DOuglas 7-2300

Robert M. Lynn
(ROLYN COMPANY) -- ESTABLISHED 1923
OPTICAL—GLASS—PHOTO
319 North Santa Anita Ave. • Arcadia, California

ADDRESS REPLY TO
P. O. BOX 745
ARCADIA, CALIFORNIA

Balzers means research in high vacuum process

For more information circle **197** on inquiry card

SEARCHLITE SECTION

CLASSIFIED ADVERTISING
EMPLOYMENT & BUSINESS OPPORTUNITIES

The advertising rate is $16.50 per inch for all Searchlite Section advertising (An advertising inch is measured 1⅛ inches vertically by 2¼ inches wide).

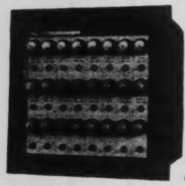
Send advertisements to INSTRUMENTS & AUTOMATION, 845 Ridge Ave., Pittsburgh 12, Pa.

Address box replies to Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 12, Pa.

Inductive & Non-Inductive
Rheostats & Resistors
Toroidal Coil Winding Mach.
Taping Machines
Winding Machines
REX RHEOSTAT CO.
BALDWIN, SO. L. I., N. Y.

For more information circle **198** on inquiry card

ANNUNCIATORS



LAMP TYPE WARNING SYSTEMS

Modern Visible and Audible Alarm Systems. Many types. Lower prices. Write for catalog. Estb. 1930.

The H. R. KIRKLAND CO.
MORRISTOWN, N. J.

For more information circle **199** on inquiry card

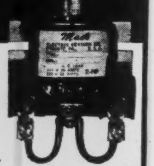
MANUFACTURERS REPRESENTATIVE

Engineer desires repeat and expendable electronic and electro-mechanical products for sale to Guided Missile and Aircraft Companies located in Southern California. Reply to:

LEE GRANT SNYDER COMPANY
Technical Sales & Contract Administrators
1418 N. Highland Ave. Hollywood 28, Calif.
Phone Hollywood 9-6278

For more information circle **200** on inquiry card

Mack
MERCURY RELAYS
Specified By Particular Engineers



hermetically sealed • no exposed arc • one moving part • silent • compact • motor loads to 2 hp., current loads to 35 amp • safeguards your application.

MACK ELECTRIC DEVICES, INC.
31 Glenside Ave., Wyncote, Pa.

For more information circle **201** on inquiry card

DESIGN ENGINEERS

INSTRUMENTS and CONTROLS

Expanding midwestern manufacturer of power and process instruments and controls in lakeside city of 30,000 with excellent schools, recreational facilities and residential areas offers permanent positions to Instrument Design Engineers. Engineering degree, preferably electrical or electronic, required.

Engineers qualifying for these positions should have experience in temperature, pressure, flow and similar functions with background in power or process industries and a practical as well as theoretical knowledge of Electronic and Electro-Mechanical Design.

Send resume to Personnel Director

The Hays Corporation
Michigan City, Indiana

C.O.M.S.I.P.

Specialised in control Engineering

Instrument layout—Procurement—Application—conventional and graphic panel design and construction

INSTALLATION—REVAMPING
STARTING UP—MAINTENANCE

40 Ave. Verdun • Croissy • S&O France

For more information circle **202** on inquiry card.

ENGINEERS
Check this list

	Price
☐ Electronic Circuitry for Instruments and Equipment by Milton H. Aronson, 1953, cloth, 310 pages.	$4.00
☐ Heat Inertia Problems of Automatic Control of Temperature by Victor Brodia, 1950, paper, 5¼" x 8¼", 61 pages.	$1.00
☐ A Romance in Research—The Life of C. F. Burgess by A. McQueen with Technical Appendix by O. W. Storey, 1951, cloth 6" x 9", 430 pages.	$6.00
☐ Scientific and Industrial Glass Blowing and Laboratory Techniques by W. E. Barr and Victor J. Anhorn, 1949, 4½" x 3", 388 pages.	$6.00
☐ Nuclear Reactors for Industry and Universities, Edited by Ernest H. Wakefield, 1954, cloth, 102 pages, 4-page index.	$2.00

Instruments Publishing Company
845 Ridge Avenue
Pittsburgh 12, Pennsylvania

☐ **Payment enclosed** ☐ **bill me**

Name ....
Company ....
Address ....

INSTRUMENTS-TEST EQUIP.

BROWN **T.C. Switching Units Model 78656-2**

48 pt. Cu-Co. Unit contains two 25 pt, 2 pole, stepping relays for switching of Cu-Co thermocouples. Can be used for other multiple circuit switching.
2 units avail.—Cost $365.00 Ex. cond. **$95 ea.**

WESTINGHOUSE MICROAMP METERS
Portable, Range 13-0-13 microamps.
4 mtrs. Cost $62. ea. Ex. cond. **$24.95 ea.**

DUMONT OSCILLOSCOPE
Model 208. New C.R. tube. Ex. cond. **$89**

WESTON 798 TUBE TESTER
5A mod. to 5B. Cost over $300 Ex. cond. **$110**

Sigma Relays **New—Orig. Mfgr. Pack**
5JO 10,000 G Sil **1 ma., 10,000 ohm SPDT 1.5a.**
5RJ 10,000 SS Pd **0.1 ma., 10,000 ohm SPDT 0.25a**
Mfgr. price $14.00. Either type **$4.95**

ESTERLINE-ANGUS Chart Movement
Panel Mt. Case. Spring mov. Ex. cond. **$39**

CRAMER TIME DELAY RELAY
Type 410, 60 sec. W.D. 303. New **$29**

THERMOCOUPLE LEAD WIRE
Fe-Co #12/2 Strd. Asbestos-Glass Braid **19c/ft.**
Chr.-Alu #12/2 Strd. Glass Braid **19c/ft.**

Write for complete list of other types

AVIONIC SUPPLY **1223 Venice Bl. Los Angeles 6, Cal.**

For more information circle **203** on inquiry card

INSTRUMENT SALES ENGINEER

Large and fast-growing industrial instrument manufacturer has openings for electrical, mechanical, or chemical engineers in Detroit, Boston and Los Angeles. Good opportunities for advancement. Should have sales aptitude with strong engineering background. Box 312.

INSTRUMENTATION ENGINEER

Due to our expansion program, a permanent position for a Mechanical or Electrical Engineer with five to ten years experience in the field of instrumentation application is available in a large pulp and paper manufacturing plant in the Upper Midwest. Our employees know of this opening. Your confidential reply should include personal, educational, and work history together with salary thinking. Write Box No. 314.

INSTRUMENT ENGINEER

Experience in Pneumatic and Electronic Instruments as applied to Oil Refinery and Chemical Plant Processing.

Also JUNIOR INSTRUMENT ENGINEER with mathematical and mechanical background and aptitude to be trained in the field of instrumentation.

These positions are in the Los Angeles area. Box 316.

FOR SALE
INSTRUMENT TESTING EQUIPMENT,

Mercurial Barometers
Meriam Manometers (various types)
Portman Optical Comparators
Paulson Time-O-Graph
Altimeter Testers
Hydraulic Presses (20-30 Ton)
Chemical Balance
Vesco Leak Detector
Pirano Gauges
Electric Ovens
Sallax Burnishing Machine
Vigor Buffer and Dust Collectors
L & R Rinsing Machine
Cold Boxes—various sizes and temperature ranges

THE LACKNER CO.
1115 York Street
Cincinnati 14, Ohio
PHONE: CHerry 1-3780

For more information circle **204** on inquiry card

COMPUTER DESIGN ENGINEER

Electronic engineer with five years' experience in analog computers to design and develop computer equipment in conjunction with the operation of a large-scale electronic analog computer facility.

Must be capable of supervising a small group of engineers and technicians.

Will also perform liaison work with outside contractor on development of a large analog-to-digital conversion system, and will participate in the design and development of an analog computer for a complex missile guidance application.

FORWARD RESUME TO
The Ramo-Wooldridge Corporation
8820 Bellanca Ave., Los Angeles 45, Calif.

NEW LITERATURE

Subminiature Switch. New 2-page data sheet describes maker's line of subminiature switches requiring small movement and low operating force.—Electro-Snap Switch & Mfg. Co., 4218 West Lake St., Chicago 24, Ill.
Circle **633** on inquiry card.

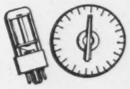
Time-Delay Relays. New 2-page Bulletin TD 402 describes standard delayed reset units, reclosure time, tolerance, operation, and special application of proportional-delayed reset time-delay relays.—A. W. Haydon Co., Waterbury, Conn.
Circle **634** on inquiry card.

Electronic Relay. New 2-page bulletin presents features of new multipurpose, sensitive electronic relay.—Industrial Electronics Co., Inc., Hanover, Mass.
Circle **635** on inquiry card.

Switches, Timers, Panels. New 4-page Catalog 4bGe presents specifications of maker's line of standard and special foot, lever, limit and push button switches; also synchronous-motor and electronic timers; also control panels.—Product Acceptance Co., 1200 Soldiers Field Rd., Boston 34, Mass.
Circle **636** on inquiry card.

Instrument Switches. New 8-page Brochure 14B 8112 describes maker's a-c rotary control and instrument switches for control-board operation of ammeters, voltmeters, frequency meters, circuit breakers, etc.—Allis-Chalmers Mfg. Co., 942 S. 70 St., Milwaukee, Wis.
Circle **637** on inquiry card.

ELECTRONIC COMPONENTS



Silicon Power Transistor. New 2-page Bulletin No. DL-S 571 describes maker's grown junction silicon power transistor (2.5-watt) especially designed for use in servo amplifier output stages.—Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.
Circle **638** on inquiry card.

Wire, Cables, Components, Hardware Catalog. New 44-page Catalog 55 presents data on maker's audio cables, battery clips, cable clamps, ignition filters, antenna kits, switches, terminal strips, wire winding machine, and hundreds of items.— Birnbach Radio Co., Inc., 145 Hudson St., New York 13, N. Y.
Circle **639** on inquiry card.

Ceramic Capacitors. New 20-page Catalog 616 presents operating data on maker's "Tiny Mike" ceramic capacitors, including temperature compensating, stabilized, general-purpose and special-purpose disc and tubular types.—Cornell-Dubilier Electric Corp., South Plainfield, New Jersey.
Circle **640** on inquiry card.

Continued on page 616

DU PONT
now has available

one career position of major responsibility
IN AUTOMATIC PROCESS CONTROL ENGINEERING

Our Engineering Service Division has immediately available a challenging position for a graduate chemical, electrical or mechanical engineer experienced in research, application, consulting, or design of automatic controls for chemical, mechanical or aeronautical applications.

Successful applicant will provide consulting advice to operating plants and development laboratories on the application of automatic control to new processes and for the improvement of existing processes. Position will require the study of process controlability by analysis of open and closed loops and the measurement of control characteristics of instrument components.

DU PONT
REG. U. S. PAT. OFF.
Better Things for Better Living
...through Chemistry

Please send complete resume, including details of education and experience, to:

Mr. J. C. Costello, Jr.
Engineering Department
E. I. du Pont de Nemours & Co., Inc.
Wilmington 98, Delaware

INSTRUMENTS and AUTOMATION

Advertisers' Index

Acromark Company 552
Aero Research Instrument Co., Inc. 595
A'G'A Division of Elastic Stop Nut Corp. of America 595
Alina Corporation 579
All American Tool & Mfg. Co. 596
American Chain & Cable Co. 605
American Phenolic Corporation 421, 422
American Time Products, Inc. 512
Amperite Co., Inc. 554
Assembly Products, Inc. 576
Associated Spring Corporation 513
Atomic Instrument Co. 570
Automatic Electric Sales Corporation 533
Automatic Switch Company 395
Avionic Supply 612

Bacharach Industrial Instrument Co. 448
Bailey Meter Company 537
Baker & Company, Inc. 397, 581
Baldwin-Lima-Hamilton Corporation 503
Barber-Colman Company 446
Barber-Colman Company, Wheelco Instruments Division 601
Barksdale Valves 549
Barton Instrument Corporation 611
Beckman, Inc., Arnold O. 558
Bendix Aviation Corporation 423
Berkeley Division, Beckman Instruments, Inc. 442
Black, Sivalls & Bryson, Inc. .... Inside Front Cover
Borg Corporation, George W. 566
Bourns Laboratories 607
Bridgeport Thermostat Div. 448
Bristol Company 412-413
Brooks Rotameter Company 559
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 454, 504-505
Bruno-New York Industries Corporation 551
Brush Electronics Company 407, 408-409, 410
Burgess Battery Company 564

Cambridge Instrument Company, Inc. 593
Chatillon & Sons, John 557
Clifton Precision Products Co., Inc. 406
Comar Electric Company 596
Commercial Research Laboratories, Inc. 458
C.O.M.S.I.P. (Instrument Control Consultant) 612
Consolidated Electrodynamics Corporation 402-403, 527, 566, 585
Cosa Corporation 592
Crawford Fitting Co. 532
Crescent Insulated Wire & Cable Co. 519
Crow Electri-Craft Corp. 576
Curtiss-Wright Corporation 432

Dahl Co., Inc., George W. 604
Davis Instruments 563
Development Engineering Company 592
Diehl Manufacturing Company 528
Dietert Co., Harry W. 549
du Pont de Nemours & Co., E. I. 613
Dwyer Mfg. Co., F. W. 597

EECO Production Company 555
Ekco Electronics, Ltd. 550
Electric Auto-Lite Company 604
Electro Instruments Inc. 531
Electronic Associates, Inc. 506
Electrons, Incorporated 571
Elgin National Watch Company 442
Eppley Laboratory, Inc. 445
Epsco Incorporated 568
Ewald Instruments 608

Fairchild Controls Corp. 608
Falstrom Company 390
Femco Inc. 570
Fisher Governor Company 404-405
Ford Instrument Company 426
Foxboro Company 398-399, 443
Frederick and Associates, Carl L. 584

Gaertner Scientific Corporation 536
General Motors Corporation 439
General Precision Laboratory, Inc. 435
German-American Trade Promotion Office 446
G-M Laboratories, Inc. 592
Gray Instrument Company 596
Green Instrument Company 598
Greiner Co., Emil 449
Gubelman Publishing Company 599
G-V Controls Inc. 589

Hagan Corporation 425
Hagen Manufacturing Company, Inc. 431
Hammarlund Manufacturing Co., Inc. 447
Hammel-Dahl Company .... Back Cover
Hasler-Tel Company 591
Hathaway Instrument Company 556
Haydon Company, A. W. 581
Hays Corporation 612
Heiland, Div. of Minneapolis-Honeywell Regulator Co. 416
Heise Bourdon Tube Company, Inc. 560
Helicoid Gage Division 605
Hewlett-Packard Company 419
H. J. J. Company 573
Hoke Incorporated 420
Hughes Research and Development Laboratories 553

Illinois Testing Laboratories, Inc. 549, 599
Impact Register Company 441
Instrof Corp. 564
International Business Machines Corp. 450
International Rectifier Corporation 553

Jackson, Byron, Division, Borg-Warner Corporation 529
Jerguson Gage & Valve Company 524
Johnson Engineering Company, Inc., Welton V. 590
Joy Manufacturing Company 424

Kearfott Company, Inc. 436
Kenyon Transformer Co., Inc. 594
Kester Solder Company 598
Keystone Valve Corp. 438
King Engineering Corp. 576
Kirkland Co., H. R. 612

Lackner Company 613
Leeds & Northrup Company 456
Lepel High Frequency Laboratories, Inc. 569
Lewis Engineering Co. 400
Librascope, Inc. 434
Lockheed Aircraft Corporation 433
Lynn, Robert M. 597, 611

Mack Electric Devices, Inc. 612
Magnatrol Valve Corp. 594
Magnetic Research Corp. 572
Mallory & Co., Inc., P. R. 541
Manning, Maxwell & Moore, Inc. 396, 514
Marsh Instrument Co. 594
Marshalltown Mfg. Co. 589
McDanel Refractory Porcelain Co. 606
Measurements Corporation 602
Mercoid Corporation 590
Meriam Instrument Company 573
Meyer-Opticraft, Inc. 567
Midwestern Instruments 460
Milford Rivet & Machine Co. 573
Minneapolis-Honeywell Regulator Co., Industrial Division 454, 504-505
Moeler Instrument Company 428
Moog Valve Co., Inc. 440
Moser Jewel Company 588

Nash Engineering Company 543
National Instrument Laboratories 591
Newark Electric Company 552
Niagara Blower Company 562
Norden-Ketay Corporation 546, 547
North American Aviation, Inc. 437
North American Instruments, Inc. 563

Offner Electronics Inc. 534
Ohmite Manufacturing Company .... Inside Back Cover

Palmer Thermometers, Inc. 538
Parker Appliance Company 575
Perkin Engineering Corp. 389
Perkin-Elmer Corporation 577
Philbrick Researches, Inc., George A. 394
Pioneer Central Div., Bendix 423
Potter Aeronautical Company 518
Powers Regulator Company 587, 599
Preis Engraving Machine Co., H. P. 602
Pritchard & Co. of California, J. F. 522, 523
Production Instrument Co. 602
Progressive Service Co. 598
P-W Industries, Inc. 544

Radiation Inc. 551
Ramo-Wooldridge Corporation 613
Recora Co., Inc. 584
Republic Aviation 545
Republic Manufacturing Co. 589
Rex Rheostat Company 612
Rubicon Company 553
Ruge Associates, Inc., Arthur C. 526

Sanborn Company 561
Schaevitz Engineering 593
Scherr Optical Tools, Inc., Geo. 591
Sensitive Research Instrument Corp. 390
Servo Corporation of America 540
Servomechanisms, Inc. 578
Shore Instrument & Mfg. Co., Inc. 574
Skinner Electric Valve Division 392
Smith Co., S. Morgan 580
Snyder Co., Lee Grant 612
Sorensen & Company 415
Sprengnether Instrument Co., Inc., W. F. 590
Stackpole Carbon Co. 595
Standard Electric Time Company 444
Statham Laboratories 609
Superior Tube Company 452
Swartwout Company 539
Synchro-Start Products Incorporated 588

Taber Instrument Corp. 430
Technical Apparatus Builders 530
Technical Charts Incorporated 603
Texas Instruments Incorporated 427
Thermo Electric Co., Inc. 610
Thermo-Couple Products Co. 565

Uehling Instrument Co. 609
Unertl Optical Co., John 574
United States Radium Corporation 579
Universal General Corp. 563

Veeder-Root Incorporated 535

Wallace & Tiernan Incorporated 429
Weckesser Co. 609
Weksler Thermometer Corporation 59
Welch Scientific Company, W. M. 52
Wendon Manufacturing Co. 60
Weston Electrical Instrument Corp. 52
Wheelco Instruments Div., Barber-Colman Company 60
Wilmad Glass Company, Inc. 58
Winzeler Manufacturing & Tool Co. 59

Zeiss, Inc., Carl 56

"No foolin' . . . a 1-year subscription to

INSTRUMENTS and AUTOMATION

ings you more than 2,000 pages of strumentation data.

e regular subscription price is .00. BUT:

n two or more new subscriptions or newals sent together on one order e rates will be reduced as follows:

2 separate one-year subscriptions	$ 6.00
3 separate one-year subscriptions	7.50
4 separate one-year subscriptions	9.00
5 separate one-year subscriptions	10.00

Offer good only in U. S. and Canada.

Other rates on page 391

Use This Subscription Card ➧

INSTRUMENTS PUBLISHING CO.
845 Ridge Avenue, Pittsburgh 12, Pa.

Please enter the following subscriptions and bill me (Company) at

Signed

Address

Name Position

Company

Products Manufactured

Address

Name Position

Company

Products Manufactured

Address

Name Position

Company

Products Manufactured

Address

Name Position

Company

Products Manufactured

Address

For additional names use another sheet F

Readers' Inquiry Card ➧

For further details concerning developments reported in advertisements, or New Product or New Literature reviews, CIRCLE THE NUMBER corresponding to that which appears with the ad or write-up.

When indicating change of address kindly note old address.

This card good ONLY in U. S. and Canada—All others should write direct.

Print—fill in COMPLETELY:

INSTRUMENTS and AUTOMATION

March '56

Good until 6-1-56

Name Title

Company

Company Address City Zone State

Products Manufactured

☐ Check for address change Show OLD address here:

Advertised Products											New Instruments										New Literature							
1	21	41	61	81	101	121	141	161	181	201	301	321	341	361	381	401	421	441	461	481	501	521	541	561	581	601	621	641
2	22	42	62	82	102	122	142	162	182	202	302	322	342	362	382	402	422	442	462	482	502	522	542	562	582	602	622	642
3	23	43	63	83	103	123	143	163	183	203	303	323	343	363	383	403	423	443	463	483	503	523	543	563	583	603	623	643
4	24	44	64	84	104	124	144	164	184	204	304	324	344	364	384	404	424	444	464	484	504	524	544	564	584	604	624	644
5	25	45	65	85	105	125	145	165	185	205	305	325	345	365	385	405	425	445	465	485	505	525	545	565	585	605	625	645
6	26	46	66	86	106	126	146	166	186	206	306	326	346	366	386	406	426	446	466	486	506	526	546	566	586	606	626	646
7	27	47	67	87	107	127	147	167	187		307	327	347	367	387	407	427	447	467	487	507	527	547	567	587	607	627	647
8	28	48	68	88	108	128	148	168	188		308	328	348	368	388	408	428	448	468	488	508	528	548	568	588	608	628	648
9	29	49	69	89	109	129	149	169	189		309	329	349	369	389	409	429	449	469	489	509	529	549	569	589	609	629	649
10	30	50	70	90	110	130	150	170	190		310	330	350	370	390	410	430	450	470	490	510	530	550	570	590	610	630	650
11	31	51	71	91	111	131	151	171	191		311	331	351	371	391	411	431	451	471	491	511	531	551	571	591	611	631	651
12	32	52	72	92	112	132	152	172	192		312	332	352	372	392	412	432	452	472	492	512	532	552	572	592	612	632	652
13	33	53	73	93	113	133	153	173	193		313	333	353	373	393	413	433	453	473	493	513	533	553	573	593	613	633	653
14	34	54	74	94	114	134	154	174	194		314	334	354	374	394	414	434	454	474	494	514	534	554	574	594	614	634	654
15	35	55	75	95	115	135	155	175	195		315	335	355	375	395	415	435	455	475		515	535	555	575	595	615	635	655
16	36	56	76	96	116	136	156	176	196		316	336	356	376	396	416	436	456	476		516	536	556	576	596	616	636	656
17	37	57	77	97	117	137	157	177	197		317	337	357	377	397	417	437	457	477		517	537	557	577	597	617	637	657
18	38	58	78	98	118	138	158	178	198		318	338	358	378	398	418	438	458	478		518	538	558	578	598	618	638	
19	39	59	79	99	119	139	159	179	199		319	339	359	379	399	419	439	459	479		519	539	559	579	599	619	639	
20	40	60	80	100	120	140	160	180	200		320	340	360	380	400	420	440	460	480		520	540	560	580	600	620	640	

NEW LITERATURE

Continued from page 613

Connectors. New 8-page issue of "Amphenol Engineering News" (Vol. 9 No. 1) features article on modular concept, shows application of maker's connectors.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle 641 on inquiry card.

Printed Circuit Connectors. Two new 2-page sheets provide descriptions and specifications for a new miniature terminal strip, printed circuit receptacle with gold plated "Bellows" type contacts, and a 35-contact pressurized connector for special applications in the guided missile field.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 642 on inquiry card.

Hermetic Terminals. New 2-page Bulletin 553 supplies technical specs on new line of high-temperature "Alsimag 567" hermetic terminals.—American Lava Corp., Chattanooga 5, Tenn.

Circle 643 on inquiry card.

TV Tubes. Two color wall charts illustrate workings of most popular color TV tubes; and provide data on almost all TV picture tubes in use today.—Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

Circle 644 on inquiry card.

Phototubes and Cathode-Ray Tubes. New 24-page descriptive catalog CRPD-105 presents maker's phototubes, camera tubes, cathode-ray tubes, monoscopes and storage tubes.—Radio Corp. of America, Harrison, N.J

Circle 645 on inquiry card.

MECHANICAL COMPONENTS

Precision Gearing. New 2-page bulletin illustrates small, close-tolerance gearing for linkage systems and electronic devices.—U. S. Gear Corp., 71 Broadway, Wakefield, Mass.

Circle 646 on inquiry card.

Identification Markers. New 4-page folder presents line of colored, vinyl, self-sticking markers for identifying pipes, wires, etc.—W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 12, Wis.

Circle 647 on inquiry card.

Beryllium Copper Strip. New 12-page Bulletin 6 presents data on maker's "Penntemp" mill-hardened beryllium copper strip.—Penn Precision Products, Inc., 501 Crescent Ave., Reading, Pa.

Circle 648 on inquiry card.

TUBING, FITTINGS

Armored Multitube. New 8-page bulletin presents maker's line of armored multitube of metal or plastic tubes with metal or plastic sheath.—Crescent Insulated Wire & Cable Co., Trenton 5, N. J.

Circle 649 on inquiry card.

Tubing, Sleeving. New 4-page Catalog 55-T is a cross-reference chart giving specifications on 26 types of plastic and Teflon sleeving and tubing.—Birnbach Radio Co., Inc., 145 Hudson St., New York 13, N.Y.

Circle 650 on inquiry card.

Pressure Hoses, Fittings. New 6-page Catalog 200 provides engineering data and descriptions of maker's high- and low-pressure hoses and accessories.—Aeroquip Corp., 300 South East Avenue, Jackson, Michigan.

Circle 651 on inquiry card.

Quick-Disconnects. New 4-page catalog provides design, technical and performance data on maker's straight-through, self-sealing disconnects.—Eastern Aircraft Products Corp., 239 River Street, Orange, New Jersey.

Circle 652 on inquiry card.

FABRICATION

Pivot Polishing. New 42-page book provides instructions and equipment data on representative's imported chip-removing and polishing machines.—Carl Hirschmann Co., Inc., 30 Park Ave., Manhasset, N. Y.

Circle 653 on inquiry card.

Drilling Units. New 2-page data sheet describes ½-hp automatic drilling units with variable-rate, air hydraulic feed.—Electro-Mechano Co., 261 E. Erie St., Milwaukee, Wis.

Circle 654 on inquiry card.

Encapsulating Machines. New 2-page Bulletin E-1255 and 4-page Bulletin 1055-0 describe maker's automatic encapsulating and casting machine for embedding and potting components and circuits.—Red Point Products, Inc., Glendale 1, Calif.

Circle 655 on inquiry card.

Visible Grinding. New 4-page brochure illustrates features of new grinding unit that provides observation of the material being removed by seeing through the grinding wheel.—Carl Hirschmann Co., Inc., 30 Park Ave., Manhasset, N. Y.

Circle 656 on inquiry card.

Simplified Drafting. New 16-page booklet "11 Ways to Save Drafting Time" describes the uses of intermediates to make modifications without changing original.—Frederick Post Co., 3666 N. Avondale Ave., Chicago 18, Ill.

Circle 657 on inquiry card.

FIRST CLASS
PERMIT No. 1441
(Sec. 34.9 P.L.&R.)
PITTSBURGH, PA.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

3c POSTAGE WILL BE PAID BY—

INSTRUMENTS and AUTOMATION
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

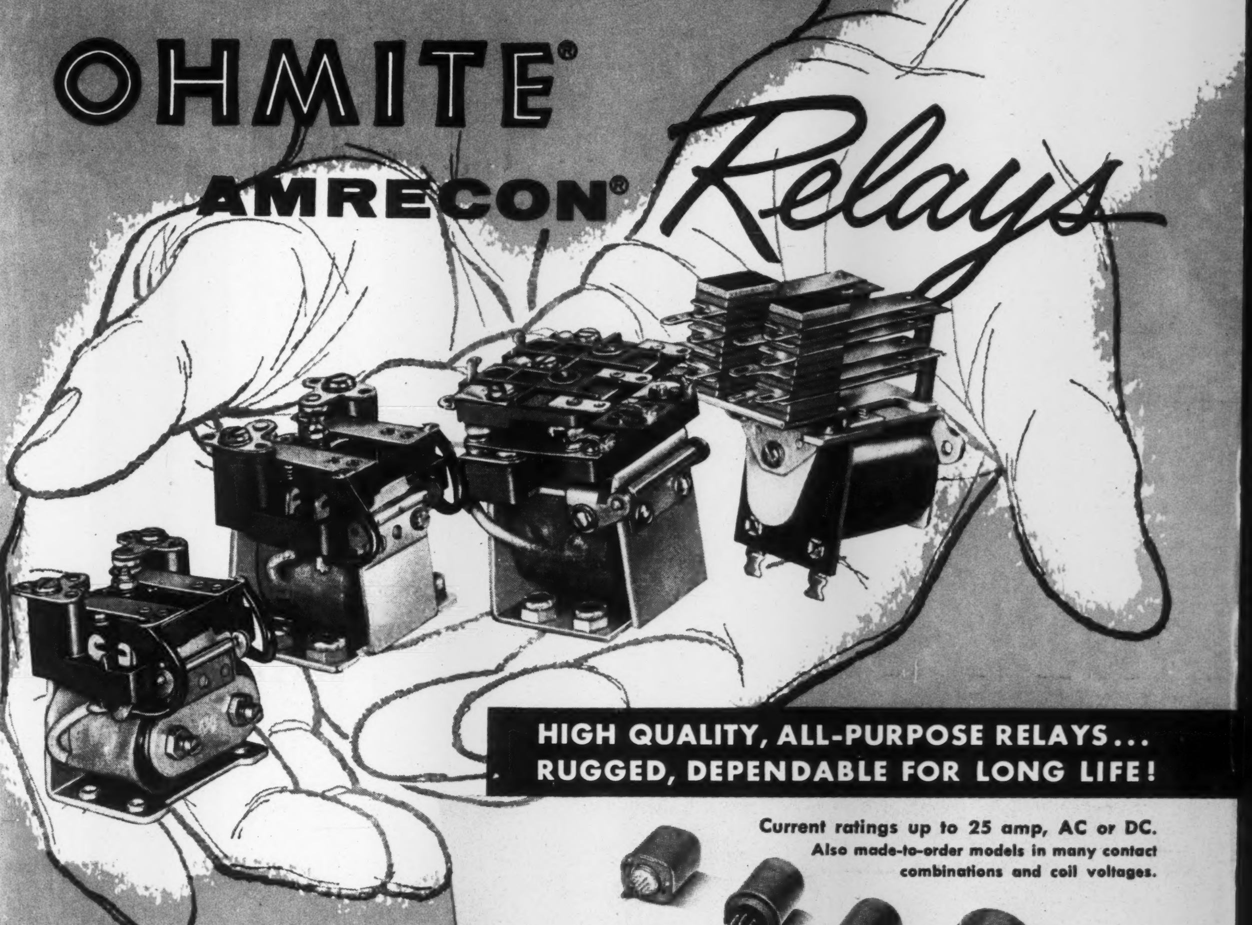
FIRST CLASS
PERMIT No. 1441
(Sec. 34.9 P.L.&R.)
PITTSBURGH, PA.

BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

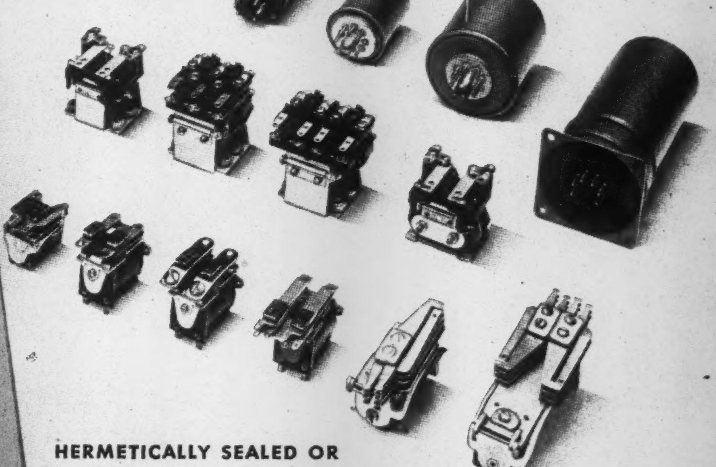
3c POSTAGE WILL BE PAID BY—

INSTRUMENTS and AUTOMATION
(Instruments Publishing Co., Inc.)
845 Ridge Avenue
Pittsburgh 12, Pa.

OHMITE®
AMRECON® *Relays*



HIGH QUALITY, ALL-PURPOSE RELAYS . . .
RUGGED, DEPENDABLE FOR LONG LIFE!



Current ratings up to 25 amp, AC or DC.
Also made-to-order models in many contact combinations and coil voltages.

HERMETICALLY SEALED OR
DUST-PROTECTIVE ENCLOSURES

65 types in four stock models

Ohmite Amrecon relays have proven their exceptional ruggedness and long life in years of service. Now, four popular stock models—DOS, DOSY, DO, and CRU, in 65 different types—are available from stock.

Models DO and DOS fill many industrial needs for a compact, lightweight relay that handles power loads usually requiring much larger, heavier units. They are particularly adaptable to aircraft and mobile equipment where severe shock and vibration are encountered. The increased operating sensitivity of Model DOSY relay, equipped with twin coils, makes the DOSY adaptable to a wide range of electronic control circuits, such as plate circuit controls. At 115 VAC or 32 VDC, noninductive load, Models DOS and DOSY have contact ratings of 15 amp; Model DO, 10 amp; and Model CRU, 5 amp. Available in a wide range of coil operating voltages and contact combinations.

Be Right with
OHMITE®
RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

AMRECON RELAYS

SEND FOR CATALOG R-10

OHMITE MANUFACTURING COMPANY
3615 Howard Street, Skokie, Illinois
(Suburb of Chicago)

For more information circle 205 on inquiry card.

THIS SINGLE-SEATED VALVE CONTROLS PRESSURE DIFFERENTIALS AS HIGH AS . . . . . .

3600 PSI with TIGHT SHUT·OFF

THE

HAMMEL-DAHL

SEAL•BALANCED

ANGLE VALVE

HOLO PLUG . . . *balanced to insure accurate positioning and optimum stability of operation.*

DAHL SEAL® . . . *eliminates leakage through the balancing port when the plug is seated.*

Nominal Sizes: 1" to 8"
Body Rating: 150# to 1500# A.S.A. STD.
Temperature Rating: To 450°F.

COMPLETE Information in H-D Bulletin 104-B

HAMMEL-DAHL COMPANY

175 POST ROAD, (WARWICK) PROVIDENCE 5, R. I., U. S. A.
SALES OFFICES IN ALL PRINCIPAL CITIES
MANUFACTURING PLANTS IN WARWICK, R. I., U. S. A., CANADA, ENGLAND, FRANCE AND HOLLAND

For more information circle **181** on inquiry card.